STATE OF MICHIGAN
CIRCUIT COURT FOR THE 7TH JUDICIAL CIRCUIT
GENESEE COUNTY

IN RE FLINT WATER LITIGATION

No. 17-108646-NO (this filing does NOT relate to all of the cases—only 16-107576-NM)

ATTORNEY GENERAL DANA NESSEL, on behalf of the People of the State of Michigan,

Plaintiff,

v

VEOLIA NORTH AMERICA, INC., a Delaware Corporation; VEOLIA NORTH AMERICA, LLC, a Delaware Limited Liability Company; VEOLIA WATER NORTH AMERICA OPERATING SERVICES, LLC, a Delaware Limited Liability Company; VEOLIA ENVIRONNEMENT, S.A., a French transnational corporation; LOCKWOOD, ANDREWS & NEWNAM, P.C., a Michigan corporation; LOCKWOOD, ANDREWS & NEWNAM, INC., a Texas corporation; LEO A. DALY COMPANY, a Nebraska corporation,

Defendants.
______________________________________/

No. 16-107576-NM

HON. RICHARD B. YUILLE

FIRST AMENDED COMPLAINT
FOR DAMAGES AND DEMAND FOR JURY TRIAL

THERE ARE NUMEROUS RELATED CASES THAT HAVE BEEN PREVIOUSLY FILED IN THIS COURT ASSIGNED TO THE HONORABLE RICHARD B. YUILLE.

Attorney General Dana Nessel, on behalf of the People of the State of Michigan, brings this Complaint for Damages for harm to the public health and general welfare of the People of the State of Michigan arising from the Flint Water Crisis.

INTRODUCTION

1. Attorney General Dana Nessel, on behalf of the People of the State of Michigan, files this civil action against the named Defendants for their roles in the events that have become known as the Flint Water Crisis, including but not limited to the corrosion of lead pipes, the leaching of lead into the water supply, and the resultant potential exposure of residents to lead and bacteria.

2. The Flint Water Crisis was a crisis of public confidence in the City of Flint's public water system based on justifiable concern over the City's bacteriological exceedances and rising water-lead levels. The City's rising water-lead levels and associated health concerns presented a significant public health threat in the fall of 2015 when the State of Michigan intervened to provide necessary social and health services and a safe source of water.

3. The Flint Water Crisis was caused by repeated failures by the City's engineering consultants, Defendant LAN and Defendant Veolia, to treat Flint's water. Though the Flint River was a treatable source of water by Defendant LAN's own analysis, Defendants failed to address design flaws in the Flint Water Treatment Plant, failed to account for changing thermal conditions within the water treatment system, and thereafter, they made multiple missteps by designing water treatment measures that made the water corrosive. Those failures ultimately resulted in bacterial problems in Flint's water, potentially dangerous disinfectant byproducts, the corrosion of the City's water distribution system, and high lead levels.

4. The Flint Water Crisis began slowly. Failures by Defendant LAN first resulted in mild corrosion that gave rise to discoloration, fecal coliform bacteria, Safe Drinking Water Act (SDWA), 42 USC 300f *et seq*., exceedances regarding water disinfectant byproducts, and moderate upticks in the City's SDWA-compliant water-lead levels. But it culminated in the late summer and early fall of 2015 after inept recommendations by Defendants had rendered the water highly corrosive, leading to substantial water-lead level increases and a then-significant problem of corrosion in the system.

5. That corrosion problem was directly traceable to Defendants LAN's and Veolia's recommendations to change from a sulfate-containing coagulant to a chloride-containing coagulant and their repeated recommendations to dump large quantities of ferric chloride into the City's water and reduce alkalinity thereby increasing the corrosivity of the water. All of these recommendations were made despite their awareness that the system was not adding any corrosion inhibitors.

6. Defendants also failed to account for the significant temperature differences between the water from Lake Huron delivered through the Detroit pipeline, and the water from the Flint River. While during the winter the water temperature from those two sources was relatively similar, during the spring, summer, and early fall the water from the Flint River was significantly warmer. As any qualified water treatment expert would have known, those temperature changes would increase the chance of breaks within the distribution system and require significant changes to the treatment process depending on the temperature.

Those temperature changes, however, did not guide Defendants' water treatment recommendation in any meaningful way.

7. The City's bacteriological problems and rising water-lead levels were thus the direct result of Defendant LAN's and Defendant Veolia's acts and omissions in serving as the City's professional experts for both designing and implementing improvements to the City's Water Treatment Plant and for evaluating and recommending adjustments to the City's water treatment equipment, processes, and operation.

8. The People of the State of Michigan relied heavily upon the hired professional expertise of the Defendant engineering firms to provide residents with safe water.

9. The Defendant engineering firms, self-proclaimed leaders and experts in water treatment and supply, failed the People of the State of Michigan.

10. The Defendants violated their legal duties and caused the Flint Water Crisis to occur, to continue, and to worsen. As a result of their conduct, the People of the State of Michigan suffered damages for past, ongoing, and future harm to public health and general welfare.

11. LAN's acts and omissions constituted professional negligence/malpractice, ordinary negligence, creation and aggravation of a public nuisance, and unjust enrichment.

12. Veolia's acts and omissions constituted professional negligence/malpractice, ordinary negligence, creation and aggravation of a public nuisance, unjust enrichment, and fraud.

13. Attorney General Dana Nessel, on behalf of the People of the State of Michigan, seeks to protect the People's interests in public health and general welfare, and to recover damages for harms to those interests.

14. Attorney General Dana Nessel, on behalf of the People of the State of Michigan, has *parens patriae* standing to bring this action to protect, and to recover damages to, the quasi-sovereign interests of the People of the State of Michigan, including the State's interest in the health and the physical and economic well-being of its citizens.

15. Attorney General Dana Nessel, on behalf of the People of the State of Michigan, requests a jury of Genesee County residents to render judgment against the Defendants on the claims stated below.

PARTIES, JURISDICTION, AND VENUE

16. Attorney General Dana Nessel, on behalf of the People of the State of Michigan, is the Plaintiff in this action.

17. "The attorney general . . . may, when in [her] own judgment the interests of the state require it, . . . appear for the people of this state in any . . . court or tribunal, in any cause or matter, civil or criminal, in which the people of this state may be a party or interested." MCL 14.28.

18. The Michigan Constitution, Art. IV, Section 51, pronounces that "[t]he public health and general welfare of the people of the state are hereby declared to be matters of primary public concern."

19. The Flint Water Crisis, arising from the acts and omissions of the Defendants, harmed the public health and general welfare of the People of the State of Michigan, including but not limited to the portion of the population potentially exposed to elevated lead levels and bacteria in the public water supply in Flint.

20. To protect the quasi-sovereign interests in public health and general welfare of the People of the State of Michigan, and to recover damages for past, ongoing, and future harms to these interests, Attorney General Dana Nessel, on behalf of the People of the State of Michigan, has standing to bring this action as *parens patriae*.

21. Attorney General Dana Nessel, on behalf of the People of the State of Michigan, is uniquely suited to bring a civil action on behalf of the quasi-sovereign interests in public health and general welfare of the People of the State of Michigan.

22. The interests at issue in this *parens patriae* action are distinct and apart from the interests of particular private parties (whether represented individually or in a putative class) at issue in other civil actions. Those include, but are not limited to, the State's expansion of services for both residents and frequent visitors of the City of Flint, including health monitoring and treatment services, mental health services, educational and social services, the provision and delivery of bottled water, the provision and delivery of in-home water filters, the replacement

of lead service lines throughout the City, and other related expenditures of public funds to protect the health and welfare of the State's residents.

23. To date, the State has appropriated approximately $350 million in support of the health and welfare of City of Flint residents and visitors by providing these services. Those funds would not have been expended but for the tortious or otherwise unlawful conduct of Defendants leading to the Flint Water Crisis.

24. The State further anticipates additional future expenditures to promote the health and welfare of City of Flint residents and visitors that are both necessitated by and the direct result of the Flint Water Crisis.

25. Defendant Veolia North America, Inc. is a Delaware corporation with its principal place of business at 200 East Randolph Drive, Suite 7900, Chicago, Illinois 60601.

26. Defendant Veolia North America, LLC is a Delaware Limited Liability Company with its principal place of business at 200 East Randolph Drive, Suite 7900, Chicago, Illinois 60601.

27. Defendant Veolia Water North America Operating Services, LLC is a Delaware Limited Liability Company with its principal place of business at 101 West Washington Street, Suite 1400 East, Indianapolis, Indiana 46204.

28. Defendant Veolia Environnement, S.A. is a transnational corporation incorporated in the Republic of France with its principal place of business at 36/38 Avenue Kléber, 75116 Paris, France.

29. The four above-named Defendants (individually and collectively Veolia) performed professional engineering services and/or engaged in other relevant conduct in Flint in 2015.

30. Veolia holds itself out as a "leading water services provider in [the] North American market, with more projects, operations, resources, expertise and demonstrated success than any other services provider."

31. Veolia maintains multiple offices in Michigan, regularly conducts business in Michigan, and has committed torts in Michigan, which are among the bases for personal jurisdiction under MCL 600.711, MCL 600.715, MCL 600.721, and MCL 600.725.

32. Defendant Lockwood, Andrews & Newnam, P.C. is a Michigan professional corporation with its principal place of business located at 1311 South Linden Road, Suite B, Flint, Michigan 48532. Lockwood, Andrews & Newnam, P.C. held itself out to the world as a Leo A. Daly Company. In 2008 Lockwood, Andrews & Newnam, P.C. was incorporated by Lockwood, Andrews & Newnam, Inc., in connection with work to be performed in Flint.

33. Defendant Lockwood, Andrews & Newnam, Inc. is a Texas corporation with its principal place of business in Houston, Texas. At all relevant times, Lockwood, Andrews & Newnam, Inc. conducted business in Genesee County, Michigan, with offices at 1311 South Linden Road, Suite B, Flint, Michigan 48532.

34. Defendant Leo A. Daly Company is a Nebraska corporation with its principal place of business at 8600 Indian Hills Drive, Omaha, Nebraska 68114. According to its website, Leo A. Daly Company's "[s]ervices are extended through Lockwood, Andrews & Newnam, Inc." In fact, Leo A. Daly Company exerts complete control over the actions of Lockwood, Andrews, & Newnam, Inc. As evidence of that control, Leo A. Daly ordinarily leases its employees to Lockwood, Andrews, & Newnam, Inc. for the performance of engineering services performed by Lockwood, Andrews, & Newnam, Inc., and it receives all revenue generated from such services. That arrangement was utilized in connection with the services at issue in this case.

35. The three above-named Defendants (individually and collectively LAN) performed professional engineering services and/or engaged in other conduct in Flint from 2011 through 2016.

36. LAN holds itself out as "a full-service consulting firm offering planning, engineering and program management services" with "firsthand knowledge of the Flint Water Treatment Plant" and its operations.

37. LAN maintains an office in Flint, Genesee County, Michigan, regularly conducts business in Michigan, and has committed torts in Michigan, which are among the bases for personal jurisdiction under MCL 600.711, MCL 600.715, MCL 600.721, and MCL 600.725.

38. Venue is proper in this Court because the original injury and damage occurred in Genesee County; Defendants reside and/or conduct business in Genesee County; the People of the State of Michigan have suffered harms and incurred costs in Genesee County; and many of the occurrences described herein occurred in Genesee County.

39. The amount in dispute is in excess of $25,000.00, exclusive of costs and attorney fees, and all of the parties have transacted business in Genesee County, Michigan at all times relevant herein such that jurisdiction is properly with this Court.

STATEMENT OF FACTS

40. The City's water service history provides the background of the Flint Water Crisis.

41. The City of Flint began operating its own Water Treatment Plant in 1917, and it placed into operation the current Water Treatment Plant (Water Treatment Plant) in 1954.

42. The City of Flint used its own water treatment plants to distribute Flint River water as the primary water supply for Flint customers for drinking and industrial uses for approximately 50 years.

43. In the 1960s, because of continued concerns regarding the capacity of the Flint River for meeting the future water supply needs of the area, the City of Flint evaluated alternatives for a new water supply.

44. In 1965, the City of Flint contracted with the City of Detroit to purchase treated water that originated from Lake Huron.

45. From 1967 to 2014, the Flint Water Treatment Plant distributed treated water via a Detroit system pipeline from Lake Huron. Flint still used the Flint River occasionally as its water source, but only as a backup water source for when Detroit water was not available and in test runs of the plant's operations.

46. Genesee County also obtained its water through Flint's relationship with DWSD. Flint and the Genesee County Drain Commissioner arranged for Flint to send some of the treated water from Detroit to Genesee County during this period.

47. Since approximately 1995, Flint distributed water from the Detroit system that had been treated with orthophosphates for corrosion control of the Flint water supply system.

48. But Flint had significant concerns with the continued use of Detroit water due to the cost of service.

49. Indeed, Flint had some of the highest water bills in the nation, and Flint actively sought to decrease those costs. Those concerns caused Flint to consider alternative water supply options for a number of years.

50. By 2009, the City of Flint, the Genesee County Drain Commissioner, and several other localities were considering the formation of the Karegnondi Water Authority (KWA) to construct a new pipeline from Luke Huron independently from the Detroit system pipeline.

51. In 2011, with Flint considering its alternatives to DWSD water, Mayor Dayne Walling commissioned LAN (in cooperation with Rowe Engineering, Inc.) to conduct a feasibility study to determine whether the Flint Water Treatment Plant could once again be used to treat the Flint River as the primary water supply for Flint, consistent with modern "rules and regulations for the treatment of surface water."

52. In response, LAN produced a July 2011 report for Flint titled "Analysis of the Flint River as a Permanent Water Supply for the City of Flint." (Ex A, LAN's 2011 Report.)

53. LAN's 2011 Report "evaluate[d] the feasibility of utilizing the City of Flint's Water Treatment Plant and Flint River as the primary water supply for the City of Flint," including "whether the Flint River is an adequate source of water for the City of Flint and identif[ying the] upgrades needed to reliably supply water on a continuous basis." (*Id.*)

54. LAN's 2011 Report recognized that "[t]here have been many new rules and regulations for treatment of surface water since 1967 when Flint's [Water Treatment Plant] was last used as a primary water supply." (*Id.*)

55. But LAN ultimately concluded after reviewing records of the characteristics of raw Flint River water that the "water from the river can be treated to meet current regulations." (*Id*. at p 7.)

56. LAN opined that treating Flint River water might require more treatment than Lake Huron water and that the "aesthetics of the finished water will be different than that from Lake Huron." (*Id.*)

57. Further, LAN noted that "the temperature of water supplied to customers during the summer will be warmer than the present Lake Huron supply, because of the increased summer temperature in the relatively shallow river." (*Id.*) In other words, because Detroit water drew from Lake Huron, a deep-water body, it was subject to less temperature variation than the Flint River would be as a water source.

58. But LAN indicated that it could "design water treatment processes and estimate operating costs" for treating Flint River water. (*Id.*)

59. LAN supplemented its 2011 Report with an Appendix titled "Technical Memorandum Cost of Service Study Flint Water Treatment Plant" (Technical Memorandum). (Ex B, LAN's Technical Memorandum.)

60. LAN's Technical Memorandum was a report that had been prepared by LAN a month earlier, which evaluated the "proposed improvements needed at the Flint River Water Plant to treat Flint River water on a continuous basis" and its likely cost. (Ex A, at p 8.)

61. LAN's Technical Memorandum detailed $49,000,000 in upgrades and improvements that would have to be made to bring the Flint Water Treatment Plant and related infrastructure up to current standards if the Flint River were to become the City's primary and permanent water source. (Ex B, at p 9.)

62. By 2012, after evaluating several options to decrease the cost of water, Flint planned to change its primary water source from the Detroit pipeline to the KWA.

63. On April 16, 2013, Flint joined the KWA—even though it would not be able to obtain water from the KWA for several more years until the new KWA pipeline was completed.

64. Flint had planned to continue obtaining water from Detroit in the interim period. But Detroit unilaterally cancelled its contract with Flint the day after Flint joined the KWA, to be effective one year later on April 17, 2014.

65. Detroit's decision left Flint with the need to obtain a different interim water source. Flint revisited LAN's previous evaluation of the Flint River as a primary water source. And in early June 2013, Flint decided to temporarily transition the Flint River from its backup to its primary source until the KWA pipeline was ready.

66. LAN eventually offered and provided (in exchange for fees), its professional engineering services to the City of Flint to design and implement improvements to the Flint Water Treatment Plant to treat Flint River water and deliver it to residents on an interim basis.

67. On June 10, 2013, LAN submitted a Proposal to the City of Flint for "Flint Water Treatment Plant Rehabilitation – Phase II." (Ex C, LAN's 2013 Proposal.)

68. LAN's 2013 Proposal was signed by J. Warren Green, Professional Engineer (Project Director), and Samir F. Matta, Professional Engineer (Senior Project Manager). (*Id.*)

69. LAN's 2013 Proposal promised to make "improvements . . . intended to help the City operate[ ] the plant on a full-time basis using the Flint River." (*Id.*)

70. LAN's 2013 Proposal claimed that "LAN's staff has the knowledge, expertise and the technical professionals to handle *all aspects* of the project. Our staff has firsthand knowledge of the Flint Water Treatment Plant . . . ." (*Id.*) (Emphasis added.)

71. LAN's 2013 Proposal included a "Scope of Services" stating the "project involves the evaluation and upgrade of the Flint Water Plant to provide continuous water supply service to the City of Flint (Flint) and its customers." In other words, LAN's proposal claimed that the upgrades to the Flint Water Plant would allow the City to safely use the Flint River as its primary water supply.

72. LAN's contract included with the 2013 Proposal sets as the "Standards of Performance" the standard of a professional engineer, stating: "Engineer [LAN] agrees to exercise independent judgment and to perform its duties under this contract in accordance with sound professional practices." (*Id.*)

73. LAN's 2013 Proposal represented that "the estimated construction cost to prepare the water plant for continuous operation using Flint River water for the interim period is on the order of $33 to $34 million." (*Id.*)

74. On or about June 26, 2013, City of Flint officials, Genesee County Drain Commissioners Office representatives, the Michigan Department of Environmental Quality (MDEQ), and design engineers from LAN held a meeting at the Flint Water Treatment Plant. (Ex D, City of Flint Responses to Citizens' Water Questions.)

75. The agenda for the meeting was to determine the feasibility of: "(1) [u]sing the Flint River as a Water Source; (2) [t]he ability to perform the necessary upgrades to the Treatment Plant; (3) [t]he ability to perform quality control; (4) [t]he ability for Flint to provide water to Genesee County; (5) [t]he ability to meet an April/May 2014 timeline; [and] (6) [d]evelopment of a cost analysis." (*Id*. at p 2.)

76. As a result of the meeting, the following determinations were made, with LAN's approval and based on its recommendations: (1) although the Flint River would require different treatment, it was identified as a viable source of water; (2) it would be "possible to engineer and construct the upgrades needed for the treatment process"; (3) "with support from LAN engineering which works with several water systems around the state, quality control could be addressed"; (4) the Flint Water Treatment Plant "would not have the capacity needed to treat and distribute sufficient water to meet the documented needs of Flint and Genesee County"; (5) "many obstacles needed to be overcome but completion by the April/May 2014 target was reachable"; and (6) "[n]ext steps from the meeting were for LAN to present the City with a proposal that would include engineering,

procurement, and construction needs for the project along with cost estimates." (*Id.*)

77. The same day, the City of Flint engaged the professional services of LAN through a "Resolution Authorizing Approval to Enter into a Professional Engineering Services Contract for the Implementation of Placing the Flint Water Plant into Operation." (Ex E, 2013 LAN Resolution.)

78. Pursuant to the 2013 LAN Resolution, the City would "enter into a Professional Engineering Services contract with LAN for the administration of placing the Flint Water Plant into operation using the Flint River as a primary drinking water source at a cost of $171,000.00." (*Id.*)

79. LAN's decision to move forward with the project to upgrade the Flint Water Treatment Plant, while knowing (1) that Flint would need to place the Plant into operation *in just 10 months* to continue to provide water to its residents; (2) the scope and extent of the upgrades needing to be implemented to enable the Plant to treat water; and (3) the lack of experience and need for training among Flint's water plant staff, was a breach of professional and ethical standards because LAN knew or should have known that a professional engineering firm adhering to professional standards of conduct could not have delivered the services promised by LAN in such a short period of time, even as a "fast-track" project.

80. From June 2013 through approximately October 2013, LAN continued to perform work under its contract with the City. But the City entered into a roughly $1 million extension of LAN's contract in the fall of 2013 to provide the City

with the engineering services needed "so that the [Water Treatment Plant] can be utilized to treat water from the river in the spring of 2014." (Ex F, Proposed Scope of Upgrades to Flint WTP, Phase II.)

81. From July 2013 through April 2014, LAN was the primary design engineering firm for the Flint Water Treatment Plant.

82. In April 2014, LAN submitted signed and sealed the improvement and upgrade plans to the Flint Water Treatment Plant as the professional engineer for the project. (Ex G, Flint Water Treatment Plant Permit Application.)

83. LAN failed to meet its duty of care and competence at a professional standard.

84. The Flint Water Treatment Plant, with upgrades designed and implemented by LAN, began distributing Flint River water on or about April 25, 2014.

85. Prior to April 2014, and since approximately 1995, Flint had been distributing pre-treated water from the Detroit system. The pre-treated Detroit water used aluminum sulfate as a coagulant and added corrosion inhibitors.

86. When the Flint Water Treatment Plant began distributing Flint River water on or about April 25, 2014, it did so without treating the new water supply with a corrosion inhibitor such as orthophosphates.

87. Further, based on LAN's recommendations, the Flint Water Treatment Plant was distributing water using ferric chloride for a coagulant rather than aluminum sulphate, the coagulant used for the Detroit system.

88. Just a few years before Flint's switch, the Water Research Foundation and the U.S. EPA addressed the effect of coagulant choice on lead leaching in a joint study entitled, "Impact of Chloride : Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water." (Ex H, CSMR Study.)

89. The CSMR Study cautioned that utilities with CSMR ratios (the ratio of chloride content over sulfide content in water) above 0.5 combined with certain pH levels "could potentially have serious lead problems following treatment changes that increase CSMR." (*Id*. at p xxiv.)

90. Treatment changes that were noted to have potential to increase CSMR levels included "changing from a sulfate-containing coagulant such as alum to a chloride-containing coagulant such as ferric chloride." (*Id*. at p xxv.)

91. Due to Defendant LAN's treatment recommendations, Flint "chang[ed] from a sulfate-containing coagulant" (aluminum sulfate) "to a chloride containing coagulant" (ferric chloride). This radically changed the chemistry of the water, and LAN compounded its mistake by not even using a corrosion inhibitor.

92. Flint's water plant operator believed the final water quality produced by the Flint Water Treatment Plant would be "scale-forming water" that would protect pipes in the distribution system from corroding and may even produce scale that "partially clo[g]" the system and cause maintenance and pressure problems. (Ex I, Glasgow email dated October 31, 2013.)

93. LAN, however, believed that the Flint Water Treatment Plant needed to use a corrosion inhibitor, and it recommended to the City to do so.

94. Despite apparent concerns that, in light of the water treatment the City was implementing with LAN's assistance, the water would need to use a corrosion inhibitor, LAN did not raise its concerns with the MDEQ.

95. Further, despite its apparent concern that the water would need to use a corrosion inhibitor, LAN failed to include corrosion control treatment equipment, such as feed pumps for phosphates, in its final designed upgrades to the Flint Water Treatment Plant.

96. LAN's failure to include corrosion control equipment in its design upgrades left the plant without even the capacity to adequately add corrosion inhibitors, such as orthophosphates, in the event that experience treating water at the plant indicated that the City needed to do so.

97. LAN's failures to design the Flint Water Treatment Plant to be able to add corrosion inhibitors, to advise MDEQ that the water treatment plan then in place required an added corrosion inhibitor, and to take other steps to prevent corrosion breached the duty of a professional engineer in this field and falls far short of the standard of care and practices of a professional engineer of ordinary learning, judgment and skill given the circumstances.

98. The danger to the public health and welfare in not addressing the need for corrosion control treatment at the Flint Water Treatment Plant was known or should have been known by LAN in light of its familiarity with and review of the data concerning the characteristics of Flint River water, its prior recommendations

to the City, and its intimate knowledge of all other treatment decisions concerning the water.

99. LAN's failure to design the Water Treatment Plant to have the capacity to implement corrosion control and its failure to raise its concerns with MDEQ breached its duty as a professional engineer and directly caused the Flint Water Crisis.

100. Problems with the Flint Water Treatment Plant's treatment of Flint River water were evident and public soon after April 2014.

101. Residents of Flint raised numerous concerns to the City of Flint regarding discoloration of the water and its smell.

102. LAN continued to provide engineering services to Flint after the re-start of the Flint Water Treatment Plant and switch to the Flint River for the City's water supply in April 2014.

103. Flint, with LAN's knowledge and agreement, repeatedly advised MDEQ that those concerns were caused by water main breaks, unauthorized opening of hydrants, broken or closed valves, system maintenance, flushing of the system, and stagnant water. Neither Flint nor LAN advised MDEQ that the concerns were caused by corrosion in the distribution system.

104. In August 2014, MDEQ notified the City of Flint that sampling in the distribution system found fecal coliform bacteria, or E. coli, that exceeded the SDWA's acute coliform Maximum Contaminant Level.

105. The Maximum Contaminant Level is defined as "the maximum permissible level of a contaminant in water that is delivered to any user of a public water supply" under Mich Admin Code, R 325.10106(c).

106. In August and September 2014, MDEQ informed the City of Flint that its water exceeded the SDWA's monthly coliform Maximum Contaminant Level, and boil water advisories were issued due to the presence of fecal coliform bacteria, or E. coli.

107. Flint and LAN both advised MDEQ that the fecal coliform bacteria or E. coli exceedances were caused by either erroneous tests or broken valves that created low pressure and allowed cross connections to leak bacteria into the system.

108. On September 10, 2014, the MDEQ issued a Compliance Communication to Flint. (Ex J, MDEQ Compliance Communication.)

109. The MDEQ Compliance Communication notified Flint that, in the preceding two quarterly periods, it had exceeded regulatory levels for trihalomethane, a byproduct of disinfection that poses health risks. (*Id.*) Although no SDWA violation had yet occurred, MDEQ anticipated that one would result from the next quarterly report. (*Id.*)

110. The MDEQ Compliance Communication further states that exceedance of trihalomethane "is an indicator of operational performance" problems with a public water supply. (*Id.*)

111. Due to the exceedance of trihalomethane, the MDEQ Compliance Communication requested that Flint complete an operational evaluation and submit a report pursuant to the Mich Admin Code, R 325.10719l. (*Id.*)

112. Flint hired LAN to conduct the operational evaluation and to prepare and submit the report required by the MDEQ Compliance Communication.

113. Defendant LAN, being hired to address these issues, had actual notice of the MDEQ Compliance Communication that the trihalomethane exceedance was "an indicator of operational performance" problems with the Flint Water Treatment Plant.

114. Around the same time, a *Flint Journal*/MLive article, "General Motors shutting off Flint River water at engine plant over corrosion worries," dated October 13, 2014, reported that General Motors announced it would no longer use Flint River water at its Flint Engine Operations plant due to high levels of chlorides in Flint's water, which had begun to corrode its products. (Ex K, 2014 General Motors Corrosion Article.)

115. The article reported that General Motors arranged to buy Lake Huron water from Flint Township (via the Detroit system pipeline), rather than rely on the Flint Water Treatment Plant and the Flint River for its water supply. (*Id.*)

116. The 2014 GM Corrosion Article included a statement by GM spokesman Tom Wickham: "Because of all the metal . . . you don't want the higher chloride water (to result in) corrosion." (*Id.*)

117. The City of Flint responded with an official statement regarding General Motors leaving the Flint water system due to problems with corrosion.

118. Flint's monthly operating reports that were sent to MDEQ provided information indicating that although the chloride levels were elevated, those levels were still within allowable limits under the SDWA.

119. Because GM's concerns were publicly reported and acknowledged by the City who had hired LAN to address related water quality issues, Defendant LAN had actual and/or constructive notice of those elevated chloride levels.

120. In November 2014, LAN issued a Draft Operational Evaluation Report for the City of Flint, titled "Trihalomethane Formation Concern." (Ex L, LAN's 2014 Report.)

121. LAN's 2014 Report was prepared in response to MDEQ's Compliance Communication regarding the exceedance of trihalomethane and the operational performance problems it indicates.

122. LAN's report explains that its task was "to determine the cause(s) of high levels of THM and evaluate possible solutions." (*Id*. at p 1.)

123. By its own terms, LAN's 2014 Report should have identified the likely causes of increased trihalomethane levels and provided appropriate recommendations to lower the trihalomethane to safe levels in compliance with state drinking water standards and professional engineering standards.

124. But LAN's 2014 Report failed to identify the root cause of the trihalomethane problem or the potential implications of this issue with regard to corrosive water.

125. Moreover, LAN's 2014 Report recommended increased ferric chloride levels. LAN's 2014 Report noted a disparity between Flint's water treatment at that time and those recommended in a 2002 Treatability Study analyzing the treatment needed for the Flint River, including a difference between Flint's then current dosage of 7.7 mg/L of ferric chloride and a recommended dosage of 40 mg/L. (*Id*. at p 9.) LAN commented that "those differences in chemical use and dosage are an obvious starting point for optimizing treatment to prevent DBP limit exceedance." (*Id*. at p 10.)

126. The following month, Flint significantly increased its ferric chloride dosage to 14.9 mg/L in response to LAN's recommendation.

127. LAN's 2014 Report also failed to account for the impact of seasonal temperature variations in making its water treatment recommendations.

128. Due to the recommendations and omissions in LAN's 2014 Report and its oral recommendations around the time of that report, including (1) its failure to identify the root cause of the TTHM exceedances; (2) its failure to identify Flint's underlying corrosion problem at that time; (3) its failure to account for temperature variations; and (4) its recommendation to increase ferric chloride dosage and increase the percent of water undergoing lime softening—all without a corrosion

inhibitor—caused the corrosion of Flint's distribution system to occur, to continue, and/or to worsen.

129. High trihalomethane levels are not only a health risk on their own, but they may also be an indicator of more serious problems with water treatment and supply.

130. A professional engineer of ordinary learning, judgment and skill in this community would view the high trihalomethane levels, along with all other publicly known and available information at the time (including but not limited to media reports of corrosive water), as reason for concern about the corrosivity of the water, the likely corrosion of pipes (including lead pipes), and a resulting increase of lead levels in the water supply and related health risks. But LAN failed to identify those concerns.

131. When Flint submitted to MDEQ its sampling results for lead and copper for the period from July 1, 2014 to December 31, 2014, the 90th percentile calculation for lead in the system was 6 ppb. Although that level was below the federal action level of 15 ppb, it was slightly more elevated than Flint's last report and should have alerted LAN to potential concerns about increasing corrosion levels.

132. A *Flint Journal*/MLive article, dated January 21, 2015, reported that over one hundred residents gathered for a public meeting on January 21, 2015, with state and local officials at Flint City Hall to express concerns with reported SDWA

violations, observed problems with drinking water quality, and concerns regarding health risks. (Ex M, Residents Unsatisfied Article.)

133. The Residents Unsatisfied article included photographs of jugs of visibly discolored water.

134. Defendants had actual and/or constructive notice of the observed problems with drinking water quality and concerns regarding health risks reported in the Residents Unsatisfied article.

135. In January 2015, in response to the violations of SDWA standards, the problems with corrosivity at the General Motors factory, the visually discolored water coming out of residents' taps, and growing public concerns over water quality and public health, the City of Flint solicited a proposal for a water quality consultant.

136. Veolia initially hesitated to submit a bid for the job. It understood that the scope of services Flint was seeking was broad and that Flint sought not only water quality recommendations but also assistance in implementing the recommendations and ongoing oversight of Flint's implementation of those recommendations. Veolia described Flint's request for bid internally as: "The City is seeking a consultant to review and evaluate the water treatment process and distribution system, provide recommendations to maintain compliance with both state and federal agencies, and *assist in implementing accepted recommendations*. The City will have the selected vendor provide reports to reflect their findings *and provide continual oversight in implementing any approved recommended practices to*

improve the quality of water until implementation of the KWA project." (Ex N, Veolia "Go/No Go" Memo dated January 22, 2015.) (Emphasis added.)

137. But the job was expected to be short-lived because the City already had a water consultant (LAN), and Veolia understood the financially strapped City would not likely pay much. Nonetheless, Veolia moved forward with the bid on the belief that it could parlay this short-lived consulting position into a much larger, $15–30 million per year "Operation and Maintenance" contract that would effectively privatize Flint's water department. Or, at least, Veolia hoped it could build this opportunity into a "Delegated Management" contract worth half that in which Veolia would assume the top management of Flint's water department.

138. With these hopes in mind but unable to assemble a bid in the time Flint originally requested, Veolia asked the City to extend the window for companies to submit bids. As no other company had submitted a bid, Flint obliged.

139. Accordingly, on January 29, 2015, Veolia submitted to the City of Flint its "Response to Invitation to Bid for Water Quality Consultant," Proposal No.: 15-573. (Ex O, Veolia's Bid.)

140. Veolia's bid was submitted by David Gadis, identified as Senior Vice President, Sales, Municipal and Commercial Development, Veolia North America.

141. Veolia's bid proposed "to address the immediate reliability and operational needs" of Flint's water system. (*Id.* at p 1.)

142. Veola's bid promised to "provid[e] immediate assistance related to the review and evaluation of the water treatment process and distribution system"; "develo[p] recommendations and a report for maintaining compliance with" state and federal regulations; and "assis[t] in implementing accepted recommendations from the report." (*Id*. at p 2.)

143. Veolia's bid explained that "addressing the fundamental issues concerning water quality compliance and operational reliability is much more complex than the recommendations study and advisory services approach outlined in [the City of Flint's request]." (*Id*.)

144. Veolia's bid therefore responded to the City's requested scope of work by proposing (1) calibrating "daily water quality samples with the City's hydraulic model"; (2) refining "the operational strategies for the plant and distribution system"; (3) coordinating "daily efforts across plant, operations and maintenance staff"; and (4) alleviating "continued concerns from the public through the public communications process." (*Id*. at p 5.)

145. Veolia's bid stated that to perform the proposed work in Flint, "Veolia would mobilize a team of experts, including our two prominent water SMEs [Subject Matter Experts], from our corporate technical services group (an in-house team of technical and management experts that support the company's project and operations throughout North America)." (*Id*.)

146. The "two prominent water subject matter experts" provided by Veolia were identified in Veolia's bid as: (1) Marvin Gnagy, P.E., "Water Process and Quality Manager," a "certified Water Operator in Ohio and a registered Professional Engineer [in Ohio]" and (2) Theping Chen, P.E., "Process and Operations Optimization Manager," a "water consulting engineer in Michigan" and "a registered Professional Engineer in the State of Michigan." (*Id.*)

147. Veolia's bid, in "Attachment 1, Resumes for Key Staff" stated that Marvin Gnagy, P.E., is the "Water Process Manager with the Engineering and Optimization group of Veolia Environnement North America (Veolia)'s Municipal and Commercial Technical Support Group." It further stated that prior to his current role with the Veolia entity described as "Veolia Environnement North America (Veolia)," Mr. Gnagy was a manager with another Veolia entity, described as "Veolia Water North America Operating Services, LLC (Veolia Water)'s Technical Direction Group." (*Id.*)

148. Veolia's bid, in "Attachment 1, Resumes for Key Staff" stated that Theping Chen, P.E., is a "Process and Operations Optimization Manager with the Engineering and Optimization group of Veolia Environnement North America (Veolia)'s Municipal and Commercial Technical Support Group." (*Id.*)

149. On or about February 4, 2015, the City of Flint engaged the professional services of Veolia through a "Resolution to Veolia Water for Water Quality Consultant." (Ex P, 2015 Veolia Resolution.)

150. The City of Flint contract approved along with that resolution includes a clause memorializing that "[t]he City is relying upon the professional reputation, experience, certification, and ability of [Veolia]." (*Id.*)

151. But, while Veolia secured this bid by outwardly portraying its involvement as providing technical assistance, it internally treated its role as principally giving the City public-relations cover and as giving Veolia an opportunity to cultivate a relationship with the City that could be leveraged into a lucrative, long-term contract.

152. Moreover, as to its technical role, Veolia's staff acknowledged to each other a few days earlier that they were promising a task they could not perform and that City residents expected them to address not merely the TTHM problem but also the City's overall water quality issues, which they could not do. Veolia engineer, Theping Chen, wrote: "[T]he City's expectation on the consultant is unrealistic. There is no small tweaking [that] will allow the City to comply with the TTHMs regulation . . . within 30–60 days. Yet, TTHMs is not even in most residents' mind. Their concerns are of overall water quality issues . . . ." (Ex Q, T. Chen email re: Scope of Work dated February 2, 2015.)

153. Robert Nicholas, a non-engineer and Veolia's Business Development manager, who took the principal role in managing this project for the firm agreed with Chen's analysis. (*Id.*)

154. Despite these private concessions, Veolia sought to publicly portray itself as providing exactly the technical assistance that would solve the City's water problems.

155. The City's outside communications consultant noted that the City had been playing up the significance of Veolia's arrival to addressing Flint's water problems, portraying it as if "the cavalry [is] coming in," and both Veolia and the City worked on public messaging to convey the message that Veolia's help would solve the City's problems. (Ex R, Memo to Edwards on Messaging re: Veolia's Role.)

156. To that end, Veolia drafted messaging points for announcing its work in Flint and highlighting its abilities, including stating: "[w]e have extensive experience in handling difficult river water sources, reducing leaks and contaminants and in managing discolored water" and that "Veolia staff consists of engineers and operators that are skilled in running this type of water facility. We would be happy to help the people of Flint, including its most vulnerable, solve their water issues and return to clear, healthy water." (Ex S, Draft Messaging Points dated February 5, 2015.)

157. Just a few days after Veolia was hired by Flint, there were public reports of lead concerns.

158. A *Flint Journal*/MLive article, dated February 9, 2015, reported that University of Michigan-Flint announced that two drinking water sources in two different buildings were being shut down due to elevated lead levels. (Ex T, Lead Test Article.)

159. Based on information reported in the Lead Test Article, the University of Michigan-Flint tested for lead levels after being notified by the City of Flint of the high trihalomethane levels in Flint's water.

160. The Defendants had actual and/or constructive notice of the elevated lead levels reported in the Lead Test Article.

161. Indeed, the City's communication consultant asked Veolia in email about the UM lead levels. Veolia responded by noting that the City should be cognizant of the UM lead problem and address it as a system-wide concern that would require the City to "operate the system to minimize this as much as possible and consider the impact in future plans." (Ex U, Nicholas email re: System Effects on Lead dated February 9, 2015.) Veolia further explained that it had previously earmarked the issue of lead leaching in the City as "something to be reviewed." (*Id.*)

162. Moreover, Rob Nicholas wrote to Marvin Gnagy the same day acknowledging that the City had a lead problem in apparent confirmation of an earlier discussion between the two. (Ex V, Nicholas email to Gnagy re: Lead dated February 9, 2015.)

163. In other words, Veolia had *actual knowledge* of UM's lead exceedances and Veolia *actually* made the connection between those issues and system-wide lead concerns in the City of Flint. But Veolia said nothing to MDEQ, to the U.S. EPA, or to the public regarding its private concerns that Flint was beginning to experience a system-wide lead issue.

164. On February 10, 2015 (one day after the University of Michigan-Flint announced that two drinking water sources were being shut down due to lead levels), the City of Flint issued a public announcement that it was hiring Veolia. (Ex W, Veolia Announcement.)

165. In the Veolia Announcement, Veolia Vice President David Gadis stated: "We understand the frustration and urgency in Flint. We are honored to support your community with our technical expertise so that together we can ensure water quality for the people of the city of Flint." (*Id.*) Mr. Gadis further represented that Veolia has "extensive experience handling challenging river water sources, reducing leaks and contaminants and in managing discolored water." (*Id.*)

166. On February 12, 2015, Veolia's Vice President Rob Nicholas made a public statement regarding the work Veolia would perform in Flint: "We're going to look at the numbers, we're going to look at the plant, we're going to decide how the equipment's functioning, look at the raw water, look at the finished water, decide how it's getting through the pipe to the house, and from that, decide how to fix each of those problems as we go forward."

167. Despite its broad public promises to fix Flint's problems, Veolia's technical review was relatively narrow in focus. Its "160-hour plan" permitted Veolia's two engineers less than two weeks to review data, hold interviews, conduct jar tests, and make recommendations in Veolia's expected interim report.

168. During that review, Marvin Gnagy conducted jar tests on ferric chloride dosing and concluded that the City, under LAN's guidance, had been significantly overdosing ferric chloride. (Ex X, Gnagy Weekly Summary of Activities Report.) Gnagy and Chen also considered using alternative coagulants to ferric chloride.

169. But Veolia's technical team was not the driving force of Veolia's involvement. Instead, the technical team admitted to each other that Veolia's Business Development team was in the driver's seat making Veolia's decisions.

170. In an email to upper management in Veolia's technical division, Joseph Nasuta noted his concerns that Veolia's Business Development team should not be making decisions in what should have been, at its core, a technical engineering-driven review. He wrote: "Just talked to Marvin [Gnagy]. ***[Business Development] is driving this*** and Marvin thinks Rob N is now looking at doing a Power Point presentation sometime next week based on what he and Theping have found this week. . . . *They plan to do only a report of the results of their jar tests.* ***Not sure what [Business Development] is trying to sell***. *Marvin thinks there will only be a Power Point presentation to Flint by BD and no long technical reporting* . . . . [Veolia] will most likely not end up with a long term [Operations &

Maintenance contract] but ***I'm not sure what is being sold to Flint other than this short consulting job***." (Ex Y, Nasuta email to Fahey.) (Emphasis added.)

171. William Fahey responded in agreement, expressing his concern about Veolia's Business Development team taking the lead, commanding: "Go on record with [Business Development] that we should advise Flint to open the valve from Detroit if we believe that is the best technical solution. ***DO NOT let BD make any technical calls. PLEASE . . . this will come back and bite us***." (*Id.*) (Emphasis added.)

172. As Veolia drafted what would become its "Interim Water Quality Report," it was Business Development—Rob Nicholas—who was the principal drafter.

173. Both Veolia's communications team and technical team reviewed the document. But Gnagy's concerns over "severely overdos[ing]" ferric chloride were not included. Nor did Veolia recommend using an alternative coagulant as Gnagy and Chen previously considered.

174. Moreover, on February 17, 2015, Bob Bowcock of Integrated Resource Management—who had performed a brief review of Flint's water treatment—confirmed Gnagy's concerns over ferric chloride dosage by noting his recommended action steps to conduct jar tests on various polymers and to reduce the use of "corrosive" ferric chloride. (Ex Z, IRM Letter dated February 17, 2015.) Veolia was aware of and reviewed Bowcock and IRM's recommendations before issuing its own report.

175. On February 18, 2015, Veolia presented its "Interim Water Quality Report" to the Flint City Council Public Works Committee. (Ex AA, Veolia's Interim Report.)

176. Veolia's Interim Report explained that Veolia would be undertaking a "detailed study" of the water system so it could "make recommendations for improving water quality," including adjusting the chemical treatment of the water. (*Id*. at pp 2, 6, & 8.)

177. As part of its analysis, Veolia promised it would "use models to predict results for . . . corrosion." (*Id*. at p 9.)

178. Even while making this promise, Veolia's Interim Report appeared to prejudge any corrosion problems, acknowledging concerns but immediately dismissing them. Veolia's Interim Report asserted that complaints of discolored water were due to "old cast iron pipes" but did not indicate "unsafe" water. (*Id*. at p 5.) Nor did Veolia identify the possibility that the discoloration was indicative of a burgeoning corrosion problem within the City's distribution system.

179. Veolia's Interim Report reported to the City and the public that Flint's water was "safe," explaining that: "Safe=compliance with state and federal standards and required testing. Latest tests show water is in compliance with drinking water standards." (*Id*. at p 3.)

180. Veolia's declaration that the water was "safe" provided an assurance at odds with its own private concerns about lead and other water quality issues. While the City was then "in compliance with drinking water standards" for lead, the

combination of indicators of corrosion in Flint's pipes and the rising lead levels in the City's test results should have alerted Veolia to the need for adjustments in the City's water treatment to avoid a looming health threat. And Veolia's public assertions that the water was "safe" belied its own private concerns that the water was causing corrosion within the system.

181. The same day it was produced, Veolia's Interim Report was made public and was reported in the media.

182. The overarching message in the media indicated precisely what Veolia intended to convey—the reassurance that the water quality issues were not indicative of any broader problems. (Ex BB, MLive article, "Despite quality problems, 'Your water is safe,' says Flint consultant.) But Veolia believed differently.

183. Additionally, Veolia's Interim Report failed to identify any lead issues, failed to mention the City's overdosing of ferric chloride, and failed to recommend the need for orthophosphates or other corrosion control treatment despite corrosion issues within the water system at that time that would have been apparent to a professional engineer of ordinary learning, judgment or skill.

184. Veolia's Interim Report likewise failed to identify the root cause of the trihalomethane problem or the implications of their recommendations in causing corrosive water.

185. Veolia likewise failed to recognize that Flint's change from using aluminum sulfate as a coagulant to using ferric chloride could cause lead leaching—despite the 2010 U.S. EPA study. Instead, Veolia doubled down on Flint's use of ferric chloride.

186. Sometime shortly after issuance of its Interim Water Quality Report, Marvin Gnagy of Veolia, while responding to concerns about an individual resident's high lead levels, privately informed Flint that he believed that Flint might have a corrosion problem and may need to add a corrosion inhibitor. (Ex CC, Glasgow email dated February 25, 2015.) Nonetheless, Veolia failed to disclose this concern to the public, failed to alert MDEQ, the U.S. EPA, or any other governmental oversight agency, and failed to include any recommendation for adding corrosion inhibitors in its written reports or statements to the public.

187. Following the issuance of its report, some Veolia staff began to question how its involvement in Flint may turn out poorly for the business company. But others held on to the hope of obtaining a $15–30 million per year long-term Operations and Maintenance contract. (Ex DD, Edwards email to Whitmore re: Prospects dated February 19, 2015.)

188. Echoing these concerns, Marvin Gnagy wrote a lengthy argument for issuing its report and leaving Flint to avoid the bad press and messy politics of working in the City. Gnagy noted: "they want the water quality issues (THM and colored water) to go away yesterday. We all know that will not happen . . . . My gut

tells me to provide a report of our findings as we said we would and walk away from this one." (Ex EE, Gnagy Walk Away email dated February 23, 2015.)

189. Rob Nicholas agreed: "The goal is to finish our report. I am done with TV." (*Id.*)

190. Nonetheless, Nicholas and the Business Development team held out hopes for a long-term Operations and Maintenance or Delegated Management contract that would bring significant revenue in for Veolia over three to five years. And they continued to press forward towards that end, even while Veolia's technical team was lamenting their involvement in Flint. As William Fahey put it: "We never should have gone in [to Flint] in the first place." (Ex FF, Fahey "Never Should Have Gone" email to Hagerty dated February 25, 2015.)

191. Around the same time, on February 27, 2015, LAN prepared a Final Operational Evaluation Report titled, "Trihalomethane Formation Concern." (Ex GG, LAN's February 2015 Report.)

192. LAN's February 2015 Report listed "ferric chloride feed rate less than 10 mg/l" as a "negative influence on THM compliance." (*Id.*)

193. LAN thus recommended additional ferric chloride to address the ongoing water quality problems, stating that "increasing the dose rate of ferric chloride is an operational change that can easily be implemented without the need for additional equipment." (*Id.* at p 13.)

194. LAN specifically recommended a dosage of 60 mg/l of ferric chloride—more than three times the dosage then in place.

195. It is widely known in the relevant engineering profession that ferric chloride is highly acidic and would increase the corrosivity of Flint's water, worsening the corrosion of lead pipes and other pipe materials, the resulting leaching of lead into the water supply, and the potential exposure of Flint residents to lead and bacteria.

196. Defendant LAN knew or should have known that adding acidic ferric chloride to Flint's water would increase the corrosivity of the water and cause such results.

197. In early March, Veolia began drafting its final Water Quality Report. Once again, Rob Nicholas, a non-engineer member of its Business Development team, was the principal drafter of both the report and an accompanying presentation.

198. On March 12, 2015, Veolia submitted to Flint its Water Quality Report. (Ex HH, Veolia's Water Quality Report.) Veolia's Water Quality Report purported to offer expertise on Flint's water treatment issues "from a utility operator's perspective" with the purpose of "solving the TTHM problem," addressing "discolored and hard water," and responding to the public's "concern about the safety of the water." (*Id*. at p 2.)

199. Veolia's Water Quality Report states that it had conducted a "160-hour assessment of the water treatment plant, distribution system, customer service and communication programs, and capital plans and annual budget." (*Id*. at p 1.)

200. Veolia's Water Quality Report failed to identify corrosion concerns within the system. Despite Marvin Gnagy's private conclusion that Flint needed to add a corrosion inhibitor and Veolia's awareness of lead concerns, Veolia continued to represent publicly that any added corrosion inhibitor was unnecessary and did not disclose its concerns over lead in this report. The report only considered corrosion inhibitors to address discoloration of the water, and it failed to mention the far more serious possibility that the discoloration indicated corrosion of the distribution system, the removal of scale, and the release of lead. (*Id*. at p 5.) Its failure to do so was even more appalling in light of Marvin Gnagy's privately expressed concerns about both corrosion and lead—indicating a breach of duty more akin to recklessness in disregarding this concern rather than mere negligence.

201. In a paragraph with a bolded heading marked "Corrosion Control," Veolia asserted that "[m]any people are frustrated and naturally concerned by the discoloration of the water with what primarily appears to be iron from the old unlined cast iron pipes. The water system *could* add a polyphosphate to the water as a way to minimize the amount of discolored water." (*Id*.) (Emphasis added.)

202. But, even then, Veolia discredited this suggestion, emphasizing that the addition of polyphosphates "WILL NOT eliminate discolored water occurrences" and cautioning against their use, even for these limited aesthetic purposes. (*Id*. at p 11.) In other words, Veolia stared Flint's corrosion problem in the face and both failed to recommend orthophosphates and also discredited the efficacy of polyphosphates or adding any other corrosion control inhibitors.

203. Not only did Veolia fail to recommend in its report for orthophosphates to be added for use as a corrosion inhibitor, but, like LAN, Veolia also disastrously suggested adding chemicals that would greatly *increase* the corrosivity of the water. Specifically, Veolia's Water Quality Report concluded that "[c]urrent ferric chloride dosages are too low and dosages of 100 mg/L or more are recommended." (*Id.*)

204. This recommendation was given even though Marvin Gnagy had expressed his belief earlier that ferric chloride was significantly overdosed. (Ex X.) Veolia's ferric chloride recommendation thus indicated that it either recklessly disregarded a known concern or that it did not base this recommendation on technical considerations because it was more concerned with solving superficial issues in order to leverage its relationship into a long-term contract than with addressing Flint's deeper water quality issues.

205. Veolia's recommended 100 mg/L dosage was *more than six times* the amount the City of Flint had been using and nearly double the level LAN had recommended.

206. To worsen matters, Veolia recommended significantly reducing the dosage of lime from 280 mg/L to 230 mg/L and to discontinue the bypass of Flint's softening system in conjunction with the recarbonation process. (*Id.* at p 4.) This resulted in a reduction of alkalinity and pH, thereby increasing the corrosivity of the treated water.

207. Veolia knew or should have known that using ferric chloride, an acid, as the primary coagulant for Flint's system and recommending repeatedly to increase its dosage would render the water intolerably corrosive and damage piping in the City's distribution system.

208. Veolia knew or should have known that reducing the dosage of lime and discontinuing the bypass of Flint's softening system in conjunction with the recarbonation process would reduce the treated water's alkalinity and pH, thereby making the water more corrosive.

209. Veolia knew or should have known that the City of Flint was not adding any corrosion inhibitors, such as orthophosphates, to its water. Veolia told the City that adding phosphates would be a needless expense that would not address the "aesthetic" concerns Veolia said it was intended to address.

210. Veolia knew or should have known that seasonal temperature variations in the Flint River water would require adjustments to its treatment recommendations.

211. Veolia's recommendation that Flint significantly increase its dosage of ferric chloride, a powerful acid, was unqualified and in no way warned the City of Flint that ferric chloride could increase corrosion.

212. Veolia's recommendations similarly failed to account for the impact of seasonal temperature variations in the Flint River water in making its water treatment recommendations.

213. Veolia failed to inform Flint that in order to increase the dosage of ferric chloride (or indeed to use any chloride at all) it must also raise the water's pH (making the water less acidic) and/or use orthophosphates to protect the pipes from corrosion.

214. The City of Flint followed both Defendants' professional advice. As a direct result, Defendants caused the corrosion of Flint's distribution system to occur, to continue, and/or worsen.

215. The catastrophic error of adding ferric chloride to already corrosive water soon came to the public's attention with objective data demonstrating the increased corrosiveness of the water beginning on or around June of 2015.

216. Indeed, Dr. Marc Edwards' Flint Water Study concluded that Flint's treated water became more acidic even as the Flint River became less acidic and found that many water samples from Flint contained high lead levels.

217. The Flint River had a pH (a measure of acidity and alkalinity) around or above 8.0 throughout the Flint Water Crisis, and its pH steadily increased (meaning it became less acidic and more alkaline) from June 2015 through October 2015. The pH in Flint's treated water, however, declined immediately after Veolia's recommendation to increase the ferric chloride concentration. The pH dropped from 7.9 in March 2015 to 7.3 by August 2015, demonstrating the impact of Veolia's recommendations on the alkalinity (and corrosivity) of the water.

218. Despite the Flint River water supply becoming more alkaline, the treated water became significantly and dangerously more acidic after and due to

Defendants' direction to add more ferric chloride, reduce lime dosage, and increase the percent of water subject to softening and recarbonation.

219. On August 27, 2015, LAN issued another Operational Evaluation Report on the Trihalomethane Formation Concern. (Ex II, LAN's August 2015 Report.)

220. Again, LAN should have recognized the root cause of the high trihalomethane levels. Again, LAN should have identified that their recommendations to reduce TTHM levels would increase corrosion. Again, LAN should have been aware of the resulting leaching of lead into the water supply and harm to public health.

221. Instead, LAN's August 2015 Report remarkably continued to recommend *additional* ferric chloride, which again would actually make the water more corrosive and intensify and worsen the Flint Water Crisis. And again, LAN failed to meet its duty of professional care and standards.

222. LAN's August 2015 Report concluded that "[i]ncreasing the dose rate of ferric chloride is an operational change that can easily be implemented without the need for any additional equipment," and LAN recommended that "[i]ncreased dosing of ferric chloride would be most ideal" with regular monitoring to determine "the appropriate ferric chloride feed rate." (*Id.*)

223. The acts and omissions of the Defendants caused the corrosion of Flint's water distribution system to occur, to continue, and to worsen. The Defendants' acts and omissions resulted in corrosive water being delivered through lead pipes into homes and other drinking water sources.

224. The corrosive water deteriorated the barrier that had previously prevented the lead in Flint's water delivery system and residents' premise plumbing from leaching into the water leaving Flint's taps. As a result, residents and visitors to Flint were potentially exposed to lead-contaminated water.

225. On September 24, 2015, researchers at Hurley's medical center announced that they had found that blood lead levels in some of Flint's children had increased since Flint's switch to the Flint River as its primary water source.

226. On October 1, 2015, the Genesee County Board of Commissioners and Genesee County Health Department issued a "do not drink" advisory to users on Flint's water system, and the Health Department declared a public health emergency.

227. On October 2, 2015, Michigan's then Governor Rick Snyder announced an action plan to address the Flint Water Crisis, including: (a) testing lead levels in Flint schools; (b) offering free water testing to Flint residents; (c) providing free water filters to residents; (d) expanding health exposure testing of individual homes; (e) accelerating corrosion controls in the Flint drinking water system; and other measures.

228. On October 8, 2015, Governor Snyder announced that the City of Flint would be switching its water supply back to Detroit water.

229. On October 15, 2015, the Legislature approved $9.3 million in relief for the City of Flint under 2015 PA 143, including $6 million to assist Flint in reconnecting to Detroit water.

230. On October 16, 2015, Flint stopped using the Flint River for its water supply and resumed use of Lake Huron water through the Detroit system. But by that time, damage to the water system and a crisis of public confidence had already occurred.

231. Additionally, because LAN had failed to design for the installation of corrosion control equipment in its plans for updating the Flint Water Treatment Plant, Flint could not immediately begin adding corrosion inhibitors in addition to those already included in the pretreated water delivered from Detroit. Instead, Flint had to obtain a permit to install the equipment, which it did not obtain until November 4, 2015.

232. LAN's failure caused delay to the planning and testing process Flint was required to follow before it could supplement the water from Detroit with corrosion inhibitors. As a result, Flint was not able to begin adding the additional inhibitors until December 9, 2015.

233. On December 14, 2015, the City of Flint declared a state of emergency in the city. That same day, the Federal Emergency Management Agency sent 28,000 liters of water for distribution to Flint residents.

234. On December 17, 2015, Flint's emergency operations center was activated to coordinate the relief efforts ordered by Flint's mayor.

235. Recognizing that the City did not have the resources to provide the required relief, the mayor met with the officials with Genesee County on December 30, 2015 to seek further assistance.

236. On January 4, 2016, Genesee County declared a state of emergency. Like Flint, Genesee County did not have enough resources to provide relief. It requested, therefore, that the State declare a state of emergency.

237. On January 5, 2016, Governor Snyder issued a Declaration of Emergency for Genesee County and activated the State's emergency operations center. The declaration stated that "the damaged water infrastructure and leaching of lead into the city's water caused damage to public and private water infrastructure and has either caused or threatened to cause elevated blood lead levels, especially in the population of children and pregnant women, and causing a potential immediate threat to public health and safety and disrupting vital community services." (Ex JJ, 2016 Snyder Declaration of Emergency.)

238. By January 9, 2016, the Michigan State Police Emergency Management Division established water resource sites providing free bottled water, water filters, and water testing kits.

239. On January 12, 2016, Governor Snyder activated the National Guard to assist with relief efforts. But like the city and county, the State sought additional assistance from another government.

240. On January 14, 2016, the State requested that the United States declare an emergency, and the United States granted the request on January 16, 2016.

241. Notwithstanding the assistance from the United States, the People of the State of Michigan carried the heaviest financial and logistical burden in providing relief for the Flint Water Crisis—a crisis Defendants caused to occur, to continue, and to worsen.

242. On January 21, 2016, the United State Environmental Protection Agency issued an Emergency Administrative Order, stating that "water provided by the City to residents poses an imminent and substantial endangerment to the health of those persons … by their ingestion of lead in waters that persons legitimately assume are safe for human consumption." (Ex KK, 2016 EPA Emergency Administrative Order.)

243. As a response to the Flint Water Crisis, the People of the State of Michigan appropriated funds to serve the residents of the City of Flint for purposes including but not limited to: (1) paying for the City of Flint to switch water sources back to the Detroit Water and Sewerage Department; (2) providing free blood-lead level testing to City residents; (3) providing and delivering bottled water; (4) providing and delivering in-home water filters; (5) replacing lead service lines for all residential properties in the City of Flint; (6) expanding of health monitoring and treatment, including mental health services; (7) expanding educational and social

services; and other actions to promote the health and welfare of citizens of this State.

244. To date, the State has appropriated nearly $350 million to address the needs of the City of Flint and its residents and visitors and respond to the crisis created by Defendants and additional future expenditures to promote the health and welfare of City of Flint residents and visitors that are both necessitated by and the direct result of the Flint Water Crisis are anticipated.

COUNT I – PROFESSIONAL NEGLIGENCE/MALPRACTICE

All Defendants

245. Plaintiff incorporates by reference all preceding allegations set forth above as if fully stated herein.

246. The Defendants undertook, for consideration, to render professional services to the City of Flint and for the benefit and protection of the public at large, including the People of the State of Michigan.

247. The Defendants undertook to perform professional services with a duty and standard of care independent of contractual obligations or statutory requirements.

248. The Defendants owed the People of the State of Michigan, including but not limited to residents and visitors of Flint, a duty of care and competence to provide engineering services at the recognized standard for professional practice within the State of Michigan.

249. That duty applied to Defendants' design of modifications to the Flint Water Treatment Plant, the decision to put the Flint Water Treatment Plant into operation in April 2014, the subsequent responses to Flint's exceedances of standards under the SDWA, all studies, reports, assessments, and treatment recommendations regarding Flint's water supply, and all statements Defendants made to the City of Flint and the public.

250. Defendant LAN breached that duty by undertaking to upgrade the Flint Water Treatment Plant so as to treat the Flint River as Flint's primary water source knowing it had just 10 months to do so.

251. Defendant LAN breached that duty because it recommended the use of the Flint River as a water source although it knew or should have known that changing to the Flint River would result in higher water temperatures and in damage to piping and degradation to the treatment process.

252. Defendant Veolia breached that duty by undertaking to resolve Flint's water quality issues when it was fully aware that it could not do so in the time permitted under its consulting contract.

253. Defendant Veolia breached that duty by failing to report to MDEQ, the U.S. EPA, and the public its acknowledged concern that in February 2015, Flint was beginning to have a system-wide lead problem despite a professional obligation to "hold paramount the safety, health, and welfare of the public." (Ex LL, Code of Ethics for Engineers, ¶ II.1.a.)

254. The Defendants breached that duty because they should have known, based on the U.S. EPA's CSMR study, that switching from aluminum sulfate to ferric chloride as the system's primary coagulant would increase the water's chloride : sulfate mass ratio and greatly increase the corrosive potential of the water.

255. The Defendants breached that duty by failing to account for the impact of seasonal temperature variations in the Flint River in making their water treatment recommendations.

256. The Defendants breached that duty by failing to recognize the root cause of the corrosion problem and to address it in the manner that a professional engineer of ordinary learning, judgment or skill in this community would do.

257. The Defendants breached that duty because they knew or should have known that Flint needed to use a corrosion inhibitor and that its failure to do so would result in damage to Flint's distribution system and the release of lead, but they nonetheless failed to require or even to recommend in their reports that Flint use a corrosion inhibitor in its water treatment.

258. The Defendants breached that duty because they failed to advise MDEQ, U.S. EPA, or the public that Flint's failure to use a corrosion inhibitor would result in damage to the distribution system and the potential exposure of residents to lead and bacteria.

259. The Defendants breached that duty because they knew or should have known that increasing the use of ferric chloride, reducing the lime dosage, and

increasing the percent of water undergoing lime softening and recarbonation, would make the water corrosive, and that would result in the corrosion of lead pipes and the potential exposure of the residents and visitors served by the City's many lead pipes to lead and bacteria.

260. The Defendants breached that duty because they had specialized knowledge regarding the functioning of the Flint Water Treatment Plant and the treatment of Flint River water and were uniquely aware of or should have been aware of the corrosion problem in Flint's water distribution system but nonetheless failed to notify the public, MDEQ, and other authorities that the water treatment plan they recommended and Flint adopted was causing the corrosion of Flint's pipes.

261. Defendant LAN breached that duty by failing to design the Flint Water Treatment Plant to be capable of adding orthophosphates or other corrosion inhibitors despite their subjective belief that such treatment would be necessary.

262. Defendant Veolia breached that duty by making multiple statements to the public downplaying any concerns over the corrosion of Flint's pipes that were false or misleading and breached their ethical duties as professional engineers. (See Ex LL, ¶ II.3.a.) ("Engineers shall issue public statements only in an objective and truthful manner.")

263. Each of these actions were breaches because they fell below the recognized standard of acceptable professional practice for licensed engineers within the State of Michigan and within Genesee County.

264. The People of the State of Michigan relied on the professional expertise and the paid work of the Defendants to provide safe drinking water, and this reliance was based, in part, on assertions and statements made by the Defendants.

265. As the direct and proximate cause of Defendants' breaches of their professional duties, the People of the State of Michigan suffered damages including but not limited to the expenditure of public funds to protect the health, safety, and welfare of Flints residents and citizens that otherwise would not have been expended.

266. WHEREFORE, Plaintiff respectfully requests that the trier of fact award damages, jointly and severally against all Defendants, including exemplary damages, and interest for all expenditures, which will fully, fairly and completely compensate the People of the State of Michigan for harm to their interests in public health and welfare.

COUNT II – NEGLIGENCE

All Defendants

267. Plaintiff incorporates by reference all preceding allegations set forth above as if fully stated herein.

268. The Defendants owed a duty to the People of the State of Michigan, including residents and visitors of Flint, to act as reasonably prudent persons.

269. The Defendants' acts and omissions, as listed in the preceding count, breached their duty to act as reasonably prudent persons in the situation they confronted. And, to the extent that any such conduct is attributed to a non-engineer

or, by law, it is not judged by the standards applicable to engineers, it nonetheless constitutes negligence.

270. Those breaches caused the Flint Water Crisis to occur, to continue, to worsen, and to ripen into a significant problem, causing corrosion of lead pipes and the potential exposure of Flint residents to lead and bacteria.

271. As a result of Defendants' conduct, the People of the State of Michigan suffered damages including but not limited to the expenditure of public funds to protect the health, safety, and welfare of Flints residents and citizens that otherwise would not have been expended.

272. WHEREFORE, Plaintiff respectfully requests that the trier of fact award damages, jointly and severally against all Defendants, including exemplary damages, and interest for all expenditures, which will fully, fairly and completely compensate the people of the State of Michigan for harm to their interests in public health and welfare.

COUNT III – PUBLIC NUISANCE

All Defendants

273. Plaintiff incorporates by reference all preceding allegations set forth above as if fully stated herein.

274. Under the common law, a person may not by act or omission create a condition which unreasonably interferes with rights common to all.

275. Defendants by the acts and omissions described above, created a condition in the City of Flint's public water system that constituted a public nuisance because it unreasonably interfered with a right common to the general public.

276. The common rights interfered with are the right to usable public drinking water, as rooted in the implicit guarantees of their contracts for water supply; the right to quiet and comfortable enjoyment of their residences, businesses, and properties; and the right to commonly utilize public facilities, including parks, libraries, schools, government offices, and other public buildings in the City of Flint.

277. The Defendants' creation of a condition—the corrosive public water and consequential damage to the City of Flint's distribution system and residents' premises plumbing—unreasonably interfered with those rights by creating threats to the public health, safety, and welfare from potential exposure to lead and bacteria.

278. The Defendants' conduct involves a significant interference with the public health, the public safety, the public peace, the public comfort and the public convenience.

279. The Defendants knew or should have known that their acts were of a continuing nature and would produce permanent or long-lasting effects upon these public rights.

280. WHEREFORE, Plaintiff respectfully requests that the trier of fact award damages, jointly and severally against all Defendants, including exemplary damages, and interest for all expenditures, which will fully, fairly and completely compensate the People of the State of Michigan for harm to their interests in public health and welfare.

COUNT IV – UNJUST ENRICHMENT/RESTITUTION

All Defendants

281. Plaintiff incorporates by reference all preceding allegations set forth above as if fully stated herein.

282. By common law and the principles of justice, a person may not be inequitably enriched by receiving a benefit at another's expense.

283. The principles of unjust enrichment are violated where a party steps in to address a duty owed by another to the public to protect the public from an urgent threat to their health, safety, or general welfare and pays expenses that rightfully should have been paid by the other person.

284. By the acts and omissions described above Defendants LAN and Veolia created the Flint Water Crisis and its associated urgent threats to the public health.

285. To resolve the crisis, the People of the State of Michigan, through their representatives, appropriated approximately $350 million to address the urgent health and welfare needs of the Flint residents and visitors arising out of the Flint Water Crisis by providing lead testing, health care, bottled water, lead service line

replacement, and other services and continues to expend or appropriate funds as necessary for those purposes.

286. Defendants received a benefit from the services provided by the People of the State of Michigan because the State's appropriations of $350 million to provide services to address the health and welfare of Flint residents relieved Defendants of obligations to address the threat to public health that LAN and Veolia were otherwise obligated to address.

287. The principles of justice and established common law require Defendants LAN and Veolia to reimburse the People for performing a duty to the residents of Flint that was properly owed by Defendants.

COUNT V – FRAUD

Defendant Veolia

288. Plaintiff incorporates by reference all preceding allegations set forth above as if fully stated herein.

289. Veolia made representations in its Interim Report, its public presentation to the Flint City Council Public Works Committee on February 18, 2015, and its Water Quality Report regarding the nature and cause of the water quality problems in Flint, the safety of Flint's water, and the public health risks that were false and material.

290. Veolia's false and material representations include but are not limited to: Veolia's statements in the Interim Report that the observed discoloration of the water was merely an "aesthetic" issue and were not indicative of a water quality

problem; Veolia's repeated assurances that the water was "safe" despite its subjective awareness that Flint was beginning to have a system-wide lead problem; and Veolia's representations in its Water Quality Report that "corrosion control" would merely address aesthetic concerns and that it would not resolve those issues.

291. Veolia had a legal and ethical duty to the residents and visitors of Flint to disclose information regarding public health risks identified in its review of Flint's water.

292. Veolia knew that the representations it made were false at the time that it made them or made the representations recklessly without concern for whether they were true. Indeed, Veolia engineer, Marvin Gnagy, privately acknowledged his belief that corrosion was a problem within the system at the same time that Veolia was publicly declaring to Flint residents and to MDEQ that such concerns were unfounded.

293. Veolia made these representations with the express intention that the general public and the People of the State of Michigan would act and rely on them. Specifically, Veolia sought to alleviate concerns about the quality of Flint's water and related health risks through its communications process, as promised to the City of Flint in Veolia's bid, in the hopes of portraying itself as resolving Flint's water quality issues in order to parlay its initial, small consulting contract into a $15–30 million per year contract to operate the City's water system for three to five years.

294. The general public and the People of the State of Michigan did in fact rely on Veolia's false representations and many residents of and visitors to Flint continued to drink and to use the water after Veolia's statements based on Veolia's false representations.

295. As a direct result of Veolia's fraudulent statements, the People of the State of Michigan have suffered, and will continue to suffer, severe economic damages.

296. The People of the State of Michigan and its citizens were in a relation of trust and confidence with Veolia when Veolia made its false and material representations.

297. WHEREFORE, Plaintiff respectfully requests that the trier of fact award damages, jointly and severally against all of the Veolia Defendants, including exemplary damages, and interest for all expenditures, which will fully, fairly, and completely compensate the People of the State of Michigan for harm to their interests in public health and welfare.

RELIEF REQUESTED

WHEREFORE, Plaintiff Attorney General Dana Nessel, on behalf of the People of the State of Michigan, demand judgment in excess of $25,000.00 for damages, including exemplary damages and interest, and such other relief as this Court may deem just and proper.

Respectfully submitted,

Dana Nessel
Attorney General

/s/ Zachary C. Larsen

Richard S. Kuhl (P42042)
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larsenz@michigan.gov

Dated: April 12, 2019

JURY TRIAL DEMAND

Plaintiff Attorney General Dana Nessel, on behalf of the People of the State of Michigan, hereby demands a trial by jury for all claims so triable.

Respectfully submitted,

Dana Nessel
Attorney General

/s/ Zachary C. Larsen
Richard S. Kuhl (P42042)
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Dated: April 12, 2019

EXHIBIT LIST

A. LAN (with Rowe Engineering, Inc.), "Analysis of the Flint River as a Permanent Water Supply for the City of Flint," July 2011 (LAN's 2011 Report)

B. LAN (with Rowe Engineering, Inc.), "Technical Memorandum Cost of Service Study Flint Water Treatment Plant," July 2011 (LAN's 2011 Technical Memorandum)

C. LAN, Proposal to the City of Flint for "Flint Water Treatment Plant Rehabilitation – Phase II," June 10, 2013 (LAN's 2013 Proposal)

D. City of Flint, Responses to City of Flint Residents' Water Questions, January 13, 2015 (City of Flint Responses to Citizens' Water Questions)

E. City of Flint, "Resolution Authorizing Approval to Enter into a Professional Engineering Services Contract for the Implementation of Placing the Flint Water Plant into Operation," June 26, 2013 (2013 LAN Resolution)

F. Proposed Scope of Upgrades to Flint Water Treatment Plant, Phase II

G. Flint Water Treatment Plant Permit Application

H. "Impact of Chloride : Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water," Joint Study by the U.S. EPA and the Water Research Foundation (2010)

I. Glasgow email dated October 31, 2013

J. MDEQ, "Compliance Communication Total Trihalomethane Operational Evaluation Requested," September 10, 2014 (2014 Compliance Communication)

K. *Flint Journal*/MLive, "General Motors shutting off Flint River water at engine plant over corrosion worries," October 13, 2014 (2014 General Motors Corrosion Article)

L. LAN, Draft Operational Evaluation Report for the City of Flint, "Trihalomethane Formation Concern," November 2014 (LAN's 2014 Report)

M. *Flint Journal*/MLive, "Officials say Flint water is getting better, but many residents unsatisfied," January 21, 2015 (Residents Unsatisfied Article)

N. Veolia "Go/No Go" Memo dated January 22, 2015

O. Veolia, "Response to Invitation to Bid for Water Quality Consultant," Flint Proposal No.: 15-573, January 29, 2015 (Veolia's Bid)

P. City of Flint, "Resolution to Veolia Water for Water Quality Consultant," February 4, 2015 (Veolia Resolution)

Q. T. Chen email re: Scope of Work dated February 2, 2015

R. Memo to Edwards on Messaging re: Veolia's Role

S. Draft Messaging Points dated February 5, 2015

T. *Flint Journal*/MLive, "University of Michigan-Flint reveals water quality test results to campus," February 9, 2015 (University of Michigan Lead Test Article)

U. Nicholas email re: System Effects on Lead dated February 9, 2015

V. Nicholas email to Gnagy re: Lead dated February 9, 2015

W. City of Flint, "Flint Hires International Urban Water Experts of Veolia North America to Assess City's Water Issues," February 10, 2015 (Veolia Announcement)

X. Gnagy Weekly Summary of Activities Report

Y. Nasuta email to Fahey dated February 13, 2015

Z. IRM Letter dated February 17, 2015

AA. Veolia, "Interim Water Quality Report," February 18, 2015 (Veolia's 2015 Report)

BB. MLive article, "Despite quality problems, 'Your water is safe,' says Flint consultant."

CC. Glasgow email dated February 25, 2015

DD. Edwards email to Whitmore re: Prospects dated February 19, 2015

EE. Gnagy "Walk Away" email dated February 23, 2015

FF. Fahey "Never Should Have Gone" email to Hagerty dated February 25, 2015

GG. LAN, Final Operational Evaluation Report, "Trihalomethane Formation Concern," February 27, 2015 (LAN's February 2015 Report)

HH. Veolia, Flint Water Quality Report, March 12, 2015 (Veolia's 2015 Report)

II. LAN, Final Operational Evaluation Report, "Trihalomethane Formation Concern," August 27, 2015 (LAN's August 2015 Report)

JJ. Governor Rick Snyder, "Declaration of Emergency for Flint," January 5, 2016 (2016 Snyder Declaration of Emergency)

KK. EPA, "Emergency Administrative Order," January 21, 2016 (2016 EPA Emergency Administrative Order)

LL. Code of Ethics for Engineers

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STATE OF MICHIGAN
DEPARTMENT OF ATTORNEY GENERAL

P.O. BOX 30755
LANSING, MICHIGAN 48909

April 12, 2019

Clerk of the Court
7th Circuit Court
900 S. Saginaw Street
Flint, MI 48502

Re: *In Re Flint Water Litigation*
7th Circuit Court Case No. 17-108646-NO

Attorney General Dana Nessel, on behalf of the People of the State of Michigan v Veolia North America, Inc., et al.
7th Circuit Court Case No. 16-107576-NM

Dear Clerk:

Pursuant to the procedures required under Paragraph 9(a) of the March 15, 2018 Confidentiality Order of *In Re: Flint Water Litigation*, Docket No. 17-108646-NO, enclosed are two versions of the First Amended Complaint being filed in *Attorney General Dana Nessel, on behalf of the People of the State of Michigan v Veolia North America, Inc., et al.*, No. 16-107576-NM. One version is redacted and the other is unredacted. Only the redacted version is being initially filed on the docket.

To comply with that Order, the Department of Attorney General (Department) has redacted all quotations from or paraphrases of any documents marked by the Veolia Defendants as "confidential" or "highly confidential." We do this despite Veolia's obvious misuse of those designations. Documents are to be marked as "confidential" or "highly confidential" under the Order if they contain, among other things, proprietary or competitively sensitive information. Despite those limitations, Veolia has applied those labels to nearly all communications and other documents it has produced in this litigation. Veolia's misuse of those designations includes, but is not limited to: marking documents directly pertinent to Veolia's actions on behalf of and recommendations to Flint as "confidential"; marking documents shared between Veolia and third-parties including the City of Flint and/or its consultants as "confidential"; and marking documents originating from third-parties and not containing Veolia-originating information as "confidential." Indeed, Veolia has gone so far as to mark even its interim and final water quality reports to the City of Flint as "confidential" (though such documents

were made available to the public at the time they were created and are already part of the public record in this case).

The Department strongly disagrees with Veolia's basis for these assertions and its attempt to shield its behavior from the public eye on a matter of such public importance as this litigation. In an effort to narrow the amount of information redacted per this Court's Confidentiality Order, the Department on April 11, 2019 informed Veolia of its belief that Veolia had improperly designated certain documents as confidential and requested Veolia waive or narrow the scope of such designation on some or all of these documents. Veolia subsequently advised that it would not have time to review the designations on those few documents prior to this filing.

Per Paragraph 9(b) of the Order, Veolia now has "fourteen [14] days to file a further motion to seal the Protected Material contained the unredacted filing, identifying (in a manner that does not disclose the substance of the Protected Material) the specific pages, lines, words, and content of such filing that such party contends meet the standard for sealing from public view under applicable law." If Veolia does not file a motion to seal within fourteen (14) days, the Department will re-file the complete Amended Complaint without redactions in the public file.

Sincerely,

/s/ Zachary C. Larsen

Zachary C. Larsen
Assistant Attorney General
Environment, Natural Resources, and
Agriculture Division
(517) 335-7664

ZCL/amm
Enclosures
cc: Parties of Record

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STATE OF MICHIGAN
CIRCUIT COURT FOR THE 7TH JUDICIAL CIRCUIT
GENESEE COUNTY

IN RE FLINT WATER LITIGATION

No. 17-108646-NO (this filing does NOT relate to all of the cases—only 16-107576-NM)

ATTORNEY GENERAL DANA NESSEL, on behalf of the People of the State of Michigan,

Plaintiff,

No. 16-107576-NM

HON. RICHARD B. YUILLE

v

VEOLIA NORTH AMERICA, INC., a Delaware Corporation; VEOLIA NORTH AMERICA, LLC, a Delaware Limited Liability Company; VEOLIA WATER NORTH AMERICA OPERATING SERVICES, LLC, a Delaware Limited Liability Company; VEOLIA ENVIRONMENT, S.A., a French transnational corporation; LOCKWOOD, ANDREWS & NEWNAM, P.C., a Michigan corporation; LOCKWOOD, ANDREWS & NEWNAM, INC., a Texas corporation; LEO A. DALY COMPANY, a Nebraska corporation,

Defendants.
______________________________________/

PROOF OF SERVICE

On April 12, 2019, I sent by email the First Amended Complaint for Damages and Demand for Jury Trial to the following parties:

cstern@levylaw.com; vinsonfcarter@gmail.com; eva.rcclawgroup@gmail.com; attybrw821@gmail.com; jimgraves@sinasdramis.com; georgesinas@sinasdramis.com; stevesinas@sinasdramis.com; stacyharkness@sinasdramis.com; fletcherwolfjc@msn.com; lfletcherj@aol.com; michaelvizard@gmail.com; trachelleyoung@gmail.com; mpitt@pittlawpc.com; cmcgehee@pittlawpc.com; brivers@pittlawpc.com; bgoodman@goodmanhurwitz.com; jhurwitz@goodmanhurwitz.com;

kjames@goodmanhurwitz.com; pnovak@weitzlux.com; jbroaddus@weitzlux.com; gstamatopoulos@weitzlux.com; hunter@napolilaw.com; pnapoli@napolilaw.com; mlmcalpine@mcalpinepc.com; jeblake@mcalpinepc.com; jweiner@cohenmilstein.com; tleopold@cohenmilstein.com; elevens@cohenmilstein.com; nhall@crisisflint.com; aoliver@oliverlg.com; Wayne.Mason@dbr.com; travis.gamble@dbr.com; david.kent@dbr.com; perickson@plunkettcooney.com; bush@bsplaw.com; williams@bsplaw.com; cthompson@swappc.com; jmoran@swappc.com; jmcampbell@Campbell-trial-lawyers.com; bmcelvaine@campbell-trial-lawyers.com; cparkerson@campbell-trial-lawyers.com; jgrunert@campbell-trial-lawyers.com; crenaud@campbell-trial-lawyers.com; wkim@cityofflint.com; berg@butzel.com; Klein@butzel.com; cbarbieri@fosterswift.com; acollins@fosterswift.com; bvandevusse@fosterswift.com; rlittleton@fosterswift.com; mpattwell@clarkhill.com; jberger@clarkhill.com; cclare@clarkhill.com; jbolton@clarkhill.com; tmorgan@fraserlawfirm.com; mperry@fraserlawfirm.com; mgildner@sfplaw.com; Bwolf718@msn.com; bmeyer@owdpc.com; tperkins@perkinslawgroup.net; nbranch@perkinslawgroup.net; pgrashoff@shrr.com; kjackson@shrr.com; alexrusek@whitelawpllc.com; Jsawin@sawinlawyers.com; vlwlegal@aol.com; deblabelle@aol.com; Cynthia@cmlindseylaw.com; shermane@cmlindseylaw.com; Stsea403@gmail.com; tbingman@tbingmanlaw.com; bjmckeen@mckeenassociates.com; mary@cndefenders.com; mwise@foleymansfield.com; gmeihn@foleymansfield.com; reriksson@cityofflint.com; jgalvin@gcdcwws.com; mcaffe@aol.com; KuhlR@michigan.gov; BettenhausenM@michigan.gov; GambillN@michigan.gov; LarsenZ@michigan.gov; tpanoff@mayerbrown.com

I declare that the above statement is true to the best of my knowledge, information, and belief.

/s/ Amy M. Mitosinka
Amy M. Mitosinka
Paralegal
Michigan Department of Attorney General
Environment, Natural Resources, and Agriculture Division
P.O. Box 30755
Lansing, MI 48909
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mitosinkaa@michigan.gov

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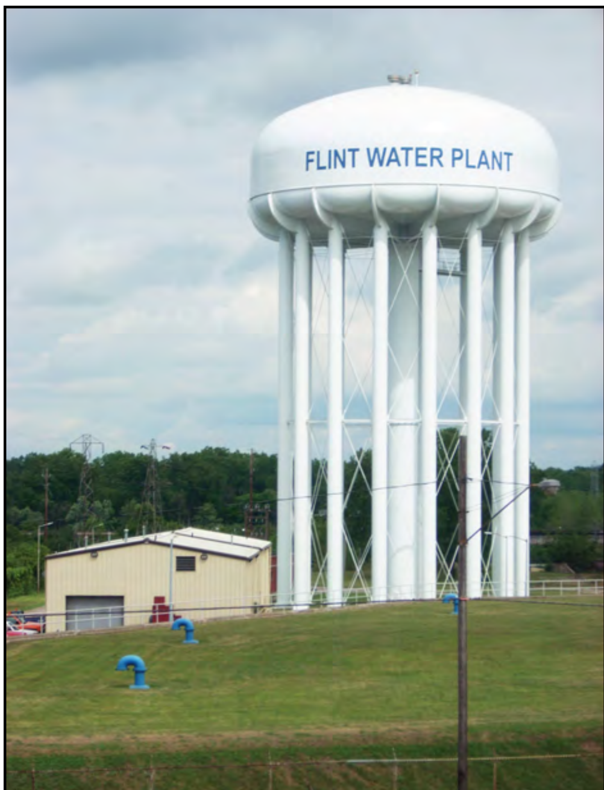
EXHIBIT A

July 2011

Analysis of the Flint River as a Permanent Water Supply for the City of Flint

Prepared for:

City of Flint
1101 S. Saginaw Street
Flint, MI 48502
(810) 766-7346



ROWE

LAN

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1. Holloway Reservoir Management Plan
2. Excerpt of Flint WWTP NPDES permit
3. Analysis of Adequacy of Flint River as a Water Supply
4. Holloway Dam Drawings
5. 2008 Holloway Dam Safety Report
6. 2008 Utah Dam Safety Report
7. 2008 Hamilton Dam Safety Report
8. Cost of Service Study – Flint Water Treatment Plant

I. Purpose

This study evaluates the feasibility of utilizing the City of Flint's Water Treatment Plant (WTP) and Flint River as the primary water supply for the City of Flint. The study evaluates whether the Flint River is an adequate source of water for the City of Flint and identifies upgrades needed to reliably supply water on a continuous basis.

II. History

The City of Flint's WTP was constructed in 1917 and supplied water to city customers for drinking and industrial uses. Records indicate that Flint supplied approximately 16 mgd in 1940 and that by the mid-1950s water use had increased to about 45 mgd. This significant increase coincided with increases in automobile production and population in the area. The Holloway Reservoir was constructed in 1954 to increase water supply capacity to meet the growing demand. Because of continued concerns regarding the adequacy of the Flint River for meeting the future water supply needs of the area, the city evaluated alternatives for a new water supply and ultimately contracted with the City of Detroit in 1967 for water supply. Detroit continues to supply water to Flint and its customers today. Detroit supplies finished water to the city via a single transmission pipeline. For reliability, the city's WTP has been maintained as a backup water supply in the event of a disruption to the single supply pipeline.

Because of recent concerns with the cost and reliability of the existing water supplies, the City of Flint, Genesee County, Lapeer County, the City of Lapeer, and Sanilac County are evaluating alternatives for their long-term water supply. The most recent study (Preliminary Engineering Report, Lake Huron Supply, Karegnondi Water Authority; September 2009) focused on two primary alternatives: Alternative 1 – continued supply by Detroit, and Alternative 2 – development of a new Lake Huron water supply. This study evaluates a third alternative. Alternative 3 provides for utilizing the existing City of Flint WTP to treat water from the Flint River. Alternative 3 assumes that water will be supplied only to customers within the city.

To evaluate the feasibility of Alternative 3, the river and WTP will be examined to determine their ability to supply water in sufficient quantity meeting current and anticipated regulations. There have been many new rules and regulations for treatment of surface water since 1967 when Flint's WTP was last used as a primary water supply.

III. Regulatory Requirements for Quantity of Source Water

Regulations require that the quantity of water at the source shall:

- Be adequate to meet the maximum projected water demand of the service area as shown by calculations based on a one in fifty year drought or the extreme drought of record, and should include consideration of multiple year droughts. Requirements for flows downstream of the intake shall comply with requirements of the appropriate reviewing authority.
- Provide reasonable surplus for anticipated growth.
- Be adequate to compensate for all losses such as silting, evaporation, seepage, etc.
- Be adequate to provide ample water for other legal users of the source.

IV. Demands

The alternative of utilizing the city's WTP and Flint River as a water supply will be evaluated on the basis of supplying water to Flint's direct customers only. Although Flint currently supplies water to GCDC-WWS, for this analysis it is assumed that GCDC-WWS receives its primary water supply by another source. Table 1 summarizes the city's current and projected demands for direct customers of the city. Projections have been provided by city representatives.

Table 1: City Customer Demand Summary

	2010	2035
Average Day Demand (ADD)	14.0 mgd	15.0 mgd
Maximum Day Demand (MDD)	17.5 mgd	18.0 mgd

Actual water requirements will be greater than the amount of water provided to customers. About ten percent additional water must be added for treatment processes and system operation. Water for fire-fighting is not included in customer demands and must be added to the quantity of water needed.

Surface water sources must be adequate to supply water through a drought period. Although the MDD is projected to be 18 mgd, the sustained maximum demand over a longer period will be less than the MDD. Analysis of records of water use indicates that the 30-day sustained maximum demand is about 80% of the MDD. Table 2 summarizes the source water requirements to supply the city's future needs.

Table 2: Source Water Requirements

Future Maximum Day Demand (Customers)		18.0 mgd
Future Maximum Day Demand (WTP Backwash / Process Water)		2.0 mgd
Subtotal (Future Maximum Day Demand)		20.0 mgd
Sustained (30 day) Future Maximum Day Demand	(80% of MDD)	16.0 mgd
Replenish Water from Fire Fighting		0.7 mgd
Future Maximum Day Demand (Source Water)		16.7 mgd

V. Drought Flows

USGS records indicate that the most severe drought in Michigan occurred between 1930 and 1937, and that the low stream flows experienced during this period have a recurrence interval of 50 to 70 years. River flow records which include the drought of the 1930s will be used to evaluate the adequacy of the river as a permanent water source.

VI. Reservoir Losses

Both the Holloway Dam and Mott Dam were constructed since the drought period of the 1930s. If used to simulate the "design drought conditions", the records of flow on the Flint River from the 1930's should be adjusted for potential impact from the addition of these two dams and resulting reservoirs.

A. Evaporation

If the two reservoirs had existed during the drought period, the flows in the river would have been a little less because of the volume of water which would have been lost to evaporation from these two bodies of water.

B. Sedimentation

The July 2001 Flint River Assessment completed by the MDNR indicates that sedimentation occurs in the Holloway Reservoir at an accelerated rate, but does not provide specific volumes. Sedimentation reduces the storage volume of reservoirs. No investigation to determine the amount of sedimentation has been completed in the Holloway Reservoir since its construction, but the storage volume of the reservoir has certainly decreased since its construction.

Mott Dam maintains a fixed water level, so storage for water supply is not available. Therefore, sedimentation in Mott Lake is not a concern with respect to water supply.

C. Seepage

The land adjacent to both the Holloway Reservoir and Mott Lake has a relatively high groundwater table. Any loss of water by seepage from the bottom of the reservoirs seems likely to flow back to the river downstream of the respective dams, resulting in little or no impact to the quantity of water available for water supply or flow augmentation. Loss from the reservoirs by seepage is not considered a significant factor.

VII. Other Water Uses

Since 1967 when Detroit began supplying water to Flint, the Holloway Reservoir has been utilized as a backup water source, source of flow augmentation for the river, and for recreational purposes. Although the city maintains control over the dam and water levels; the city has leased their surrounding lands to the Genesee County Parks and Recreation Commission (GCPRC) for park, recreational, and conservation purposes. In 1987, the city and GCPRC adopted the Holloway Reservoir Management Plan (HRMP) which defined how water levels in the reservoir were to be maintained to achieve the goals above. The HRMP establishes a summer water level of 755 and a winter level of 751. Discharge from the reservoir is to be maintained above 65 cfs except when the level is less than 751; outflow from the reservoir is not to exceed inflow to the reservoir. A copy of the HRMP is included in Appendix 1.

Flow augmentation for the city's WWTP discharge is another consideration. The city's NPDES permit for their WWTP indicates that a Flint River drought flow of 85 cfs was used to determine the permitted limits for WWTP effluent. It appears that the HRMP requirement to maintain a 65 cfs minimum at the Holloway Reservoir was established to provide adequate flow in the river at the city's WWTP outfall. An excerpt of the city's WWTP NPDES permit is included Appendix 2.

The existing water supply contract between the city and Genesee County Drain Commissioner Division of Water and Waste Services (GCDC-WWS) provides that both the city and GCDC-WWS supply the other up to 8 mgd of finished water in the event of an emergency or supply disruption. For this analysis, it is assumed that the Flint WTP and river must be able to supply 8 mgd to GCDC-

WWS in the event of an emergency in addition to the quantity consumed by the city's water customers. The need to provide backup to GCDC-WWS is assumed to be limited to a period of two weeks. Over a 14 day period, 125 million gallons of water should be reserved to meet the commitment for an emergency supply.

VIII. Analysis of Adequacy of Flint River

A detailed analysis of the adequacy of the Flint River as a water supply source is included in Appendix 3. This section provides an overview.

In 1977 when the HRMP was executed, water was not withdrawn from the Flint River for water supply. In 1977 without any withdrawal for water supply, the HRMP provided for a minimum discharge of 65 cfs from the Holloway Reservoir, to provide for a river flow of 85 cfs at the city's WWTP. If water is withdrawn from the river for water supply, the minimum flow from the reservoir must be increased by the rate of WTP withdrawal if the 85 cfs base flow is to be maintained at the city's WWTP. With Flint's future sustained demand estimated to be 16.7 mgd (26 cfs), a minimum flow of 91 cfs (65 cfs + 26 cfs) will be needed from the Holloway Reservoir to maintain the 85 cfs base flow at the WWTP.

The United States Geological Survey (USGS) in a 1963 report Water Resources of the Flint Area Michigan examined the Flint River as a water supply for Flint. Using river flow records between 1930 and 1952, the USGS report includes a Draft-Storage curve for the Holloway Reservoir. If a minimum discharge of 91 cfs is to be maintained during a drought period, 6.2 billion gallons water would need to be withdrawn from the reservoir to supplement natural river flow.

In addition to the 6.2 billion gallons of storage to maintain the existing rates of flow in the river plus water supply, additional storage is required to provide GCDC-WWS an emergency supply and to make up for reservoir losses. The following table summarizes the total storage needed.

Table 3: Storage Requirements

Storage to meet sustained demand and WWTP flow	6.20	billion gallons
Storage to provide backup supply to GCDC-WWS	0.11	billion gallons
Storage to make up loss by evaporation	0.90	billion gallons
Storage lost by siltation	0.64	billion gallons (assumed)
Storage to provide loss by seepage	0.00	billion gallons
Storage Needed to Supplement River Flow	7.85	billion gallons

To provide 7.85 billion gallons of storage, the Holloway Reservoir operating level must be raised by at least three feet to 758 feet. Although possible, there are many challenges associated with operating the Holloway Reservoir at the 758 feet level.

- The existing drum gates used to control reservoir level are designed for adjustment over a four feet range (751 feet to 755 feet). The design of the dam is such that the existing gates cannot simply be replaced with larger ones to increase the upper level to 758 feet. The dam spillway will likely need to be reworked to accommodate the larger drum gates. Drawings showing the details of the dam are included in Appendix 4.

- Although operation at the 758 water level provides five feet of freeboard to the top of the dam, the watershed contributing to the reservoir is quite large and has resulted in quick increases in the reservoir level during extreme rain events. The reduction in freeboard will result in a reduced safety factor for managing flood events.
- Seepage through the earthen dam embankment will increase as a result of the increased hydraulic pressure with the higher water level. Increased seepage through the dam's embankment will reduce the strength and integrity of the embankment and is likely to increase maintenance needs.
- The 758 feet water level is based on an assumption regarding the loss of the reservoir volume by siltation. The depth of siltation should be measured to better determine the quantity of siltation and its impact on storage and reservoir level.
- Recreational activities, the fishery, and adjacent properties will be impacted by use of the reservoir for water supply. Normal water levels will be increased by three feet and during dry periods, the water levels may vary by several feet. During an extreme drought period, water levels may be as much as 11 feet below normal levels.
- If the 85 cfs drought flow at the city's WWTP cannot be achieved, a new NPDES permit with stricter discharge limits may issued by the MDEQ. This could result in higher WWTP costs for the city.

Analysis shows that without modification, the Holloway Reservoir can support a sustained maximum day demand of 11.6 mgd for water supply through a drought period.

IX. Dams

If the Flint River is to be used as water supply, existing dams will continue to be critical for management of the flows in the river and water supply. Following is a summary of the dams on and adjacent to the river.

Table 4: Summary of Dams

Facility	Construction Completed	Catchment Area (sq. mi.)	Surface Area (Acres)	Storage (Acre-Feet)	Ownership	Hazard Classification	Condition
Holloway Dam	1954	523	1,973	17,678	Flint	High	Good
Mott Dam	1972	612	684	0	GCPRC		Good
Kearsley Dam	1929	115	175	2,000	Flint	Significant	Satisfactory
Utah Dam	1928	729		0	Flint	Low	Poor
Hamilton Dam		748	17		Flint	High	Poor
Thread Creek Dam	1973	63	80	320	Flint	Significant	Poor

A. Holloway Dam

The Holloway Dam was last inspected in 2008 and was reported to be in good condition. A copy of the 2008 Dam Safety Report is included in Appendix 5. Other than routine maintenance, the following upgrades / modifications are recommended to provide a water supply of up to 11.6 mgd:

- Replacement of drum gate bearings
- Installation of river flow gage on North Branch of Flint River
- Improved instrumentation to measure and monitor gate positions and water surface level

If the river is to be used as a water supply of greater capacity than 11.6 mgd, additional modifications are required at the Holloway Dam to allow for operation at an increased water level. These improvements will include replacement of gates with larger ones and reworking of the dam spillway to accommodate the larger gates. The existing embankment should be armored to strengthen the dam's embankment and protect against erosion from wave action. A budget of $2.57 million is established for the upgrades to the Holloway Dam to provide adequate capacity for the projected future demands.

B. Mott Dam

The Mott Dam is under the jurisdiction of the GCPRC. The reservoir level is maintained by a fixed weir so the reservoir volume is not available for storage. The dam has been reported to be in good condition.

C. Utah Dam

Utah Dam is inoperable and in poor condition. A copy of the 2008 Dam Safety Report is included in Appendix 6. Recent studies and evaluations conclude that the dam is of little benefit and should be removed. The 2010 Hamilton Dam Modifications and Riverfront Restoration PER provides a budget of $1.9 M for removal of the Utah Dam, including replacement with a pedestrian bridge, construction of a boat launch, and local storm sewer upgrades.

D. Hamilton Dam

The Hamilton Dam is in poor condition and considered unstable. A copy of the 2008 Dam Safety Report is provided in Appendix 7. The dam has been the subject of extensive study and recommended for removal and replacement. The 2010 Hamilton Dam Modifications and Riverfront Restoration PER provides a budget of $7.1 M for the removal and replacement of the dam, including ancillary upgrades to adjacent portions of the river.

The new Hamilton Dam is proposed at a lower elevation than the existing dam to reduce potential for flooding. A reduced water level upstream of the dam will reduce the water pool depth at the WTP intake, unless the Utah Dam is replaced or another dam is added. Testing of pumps at the WTP was completed to determine the impact of a reduced water depth at the WTP intake. Allowing for two feet of loss through the WTP intake screens after operation, reduction of the height of the Hamilton Dam by 1.5 feet or more will impact WTP's ability to draw water from the river.

E. Kearsley Dam

The Kearsley Dam is reported in satisfactory condition. Although the dam is located downstream of the city's WTP, water from the dam and Kearsley Lake supplements the river flow in advance of the Hamilton Dam, therefore contributing to the impoundment from which the WTP draws water. Water from the Kearsley Creek also serves to augment river flow at the city's WWTP located further downstream.

The storage volume of Kearsley Lake is relatively minor in relation to the storage deficit from Section VIII. Supplemental flows to the river from the Kearsley Creek are included in the USGS records included in this analysis

The dam is an important component of the city's water supply system because of its potential contribution to the WTP intake. Although currently in satisfactory condition, there will be ongoing maintenance needs to be addressed.

F. Thread Lake Dam

The Thread Lake Dam is reported to be in poor condition. Flow from the Thread Creek supplements the river flow prior to the city's WWTP. The storage provided by Thread Lake is negligible and flow from Thread Creek is included in the USGS records of river flow used for this analysis.

The Thread Lake Dam remains a facility of the city which because of its poor condition needs to be addressed. However, since the dam appears to be of little benefit to the water supply considered in this analysis, a budget for upgrades or removal has not been included in the costs for water supply.

X. Source Water Quality

Since the Flint WTP is the backup water supply in the event of a disruption to the supply from Detroit, raw water at the WTP intake is regularly sampled and analyzed. Available records provide a good understanding of the characteristics of the raw water and ranges of variances, and will be helpful to design water treatment processes and estimate operating costs.

Preliminary analysis indicates that water from the river can be treated to meet current regulations; however, additional treatment will be required than for Lake Huron water. This results in higher operating costs than the alternative of a new Lake Huron supply.

Although water from the river can be treated to meet regulatory requirements, aesthetics of the finished water will be different than that from Lake Huron. As an example, the temperature of water supplied to customers during the summer will be warmer than the present Lake Huron supply, because of the increased summer temperature in the relatively shallow river.

A detailed investigation of potential sources of contamination has not been completed. The MDEQ has reported that the Richfield Landfill is considering an application for an NPDES permit to allow

for discharge of stormwater and/or treated leachate to the Holloway Reservoir. If an NPDES permit is issued, there may be an impact on the quality of source water.

If used for water supply, a source water protection management plan should be developed to study the watershed, identify potential sources of contamination, and enact safeguards to prevent or control future threats.

XI. Water Treatment

For comparison with other alternatives, it is assumed that the Flint WTP will treat water from the river to provide a finished water of similar quality to the other alternatives being considered (continued Detroit supply and new Lake Huron supply).

A review of the city's WTP has been completed (Technical Memorandum, Cost of Service Study, Flint Water Treatment Plant prepared by Lockwood, Andrews, and Newnam (LAN), dated June 2011) to evaluate its ability to treat water from the river on a continuous basis to meet current and anticipated regulations and produce high quality finished water. Details regarding this review and analysis are provided in Appendix 8.

Although the WTP has been maintained and operated as a backup water supply, there have been numerous changes in regulations and standards since the WTP last supplied water on a continuous basis. Although equipment and systems at the WTP have been used sparingly, some existing equipment and systems require replacement from deterioration or obsolescence to provide reliability for continuous operation.

Following is a summary of upgrades needed.

A. Lime Sludge Disposal

Prior to supply of water by DWSD, the city's WTP disposed of lime sludge from water treatment operations at the Bray Road disposal site. The city is working with the MDEQ to address concerns at the Bray Road site; for this study it has been assumed that new sludge handling and disposal provisions will be utilized. Lime residual handling and disposal facilities have an estimated project cost of $15.1 million. No costs have been included for remediation of the Bray Road site.

B. Soda Ash Feed System

Records of analyses of the source water indicate non-carbonate hardness. To remove the non-carbonate hardness and provide softening, soda ash should be added during treatment. The addition of a soda ash feed system has an estimated project budget of $0.5 million.

C. Chemical Storage

Bulk chemical storage of at least 30 days is needed if the plant operates on a continuous basis. New storage tanks for liquid carbon dioxide, liquid oxygen, and liquid nitrogen will be needed. The project budget for chemical storage is $2.1 million.

D. Electrical and SCADA

The power requirements of equipment at the WTP exceed the capacity of the substation which supplies the plant. Backup power generators at the WTP are not currently operable. Upgrades are recommended to power feeders for several of the existing systems. New SCADA is recommended to provide control and monitoring of operations at the WTP. The project budget for these upgrades is $8.1 million.

E. Post Chlorination and Zebra Mussel Control

Zebra mussels are an invasive shell fish which have been introduced to the Great Lakes basin, including the Flint River. Zebra mussels can obstruct pipes and water intake screens. A sodium permanganate feed system is proposed for zebra mussel control. The project budget is $0.3 million.

F. Security Issues

Additional security measures to guard against malevolent threats or terrorism which target the new water source will be required. A project budget for this is $0.3 million.

G. Pumping System Improvements (Low and High Service Pumps in PS No. 4)

The pumps are in poor condition and their capacity is not consistent with the projected demands of the city. The pumps should be replaced with new, more efficient pumps. The project budget for these is $7.8 million.

H. Filter Transfer Station to Dort Reservoir and UV Inactivation

Recent USEPA regulations require additional treatment or enhancement of existing treatment processes for microbial contaminates such as giardia, cryptosporidium, viruses, and bacteria. It is anticipated that enhanced contact time and ultraviolet light deactivation will be required to comply with these new standards. A project budget of $7.0 million is established for compliance with the new surface water treatment rules.

I. Emergency Interconnect

The GCDC-WWS and City of Flint have a mutual aid agreement providing for each to provide the other up to 8 mgd of water as a back-up supply in the event of an emergency with either system's supply. A pumping station and piping interconnect is needed to effectively complete this exchange. The project budget for these upgrades is $8.6 million.

The total of all WTP upgrades above is $49.9 million.

In addition to upgrades to the treatment plant, there will be increased operating costs associated with the continuous operation of the WTP. For comparison with other alternatives for a long-term water supply, only the additional operational costs have been determined.

- Labor – Full scale operation of the WTP and dams on a continuous basis will require additional staffing. It is estimated that labor costs will increase by $2,034,000 per year.
- Chemicals – The cost of chemicals used for water treatment are estimated at $423 per million gallons of water produced.
- Residual Disposal – Disposal costs for lime sludge is estimated to be $453,000 annually.

- Power – Increased power costs are estimated to be $104 per million gallons of water produced.
- Ozone – Ozone treatment will be needed to meet new treatment standards. A budget of $208,000 is assumed.
- Maintenance – Maintenance costs are assumed to be 20% of the O&M budget. Maintenance costs of the WTP and other facilities are expected to be relatively high because of the age of the facilities.

XII. Cost Summary

Upgrades to dams and the WTP will be needed for the Flint River to reliably supply drinking water on a continuous basis to Flint's customers. The cost of these upgrades is presented in the following table. Costs have been adjusted to an ENR Construction Cost Index of 8688 to allow for comparison with the 2009 Study. It has been assumed that design/construction commenced in 2010, to allow for comparison with the alternatives in the 2009 study.

Table 5: Project Costs

WTP Upgrades	$49,888,000
Hamilton Dam Replacement	$7,100,000
Holloway Dam /Reservoir Upgrades	$2,570,000
Utah Dam Removal	$1,900,000
Total Capital Cost	**$61,458,000**

Costs shown are based on upgrades to existing facilities to supply the projected future maximum day demand of 18.0 mgd. These upgrades are based on the assumption that the HRMP is modified to allow for operation over a greater range of water levels. Other options for supplying the projected maximum day demand will result in higher costs.

Operating costs in the initial year of operation are estimated to increase $7 million above current operating costs. Operating costs are projected to increase annually because of inflation and projected growth in demand over the study period.

Figure 1 shows the cost of water for Alternative 3, utilizing the existing WTP and Flint River for water supply. The cost of water is comprised of three components: continued purchase of water from Detroit during construction, debt for construction of facility upgrades, and ongoing operating costs.

Figure 1: Cost of Water Using Flint River as Source

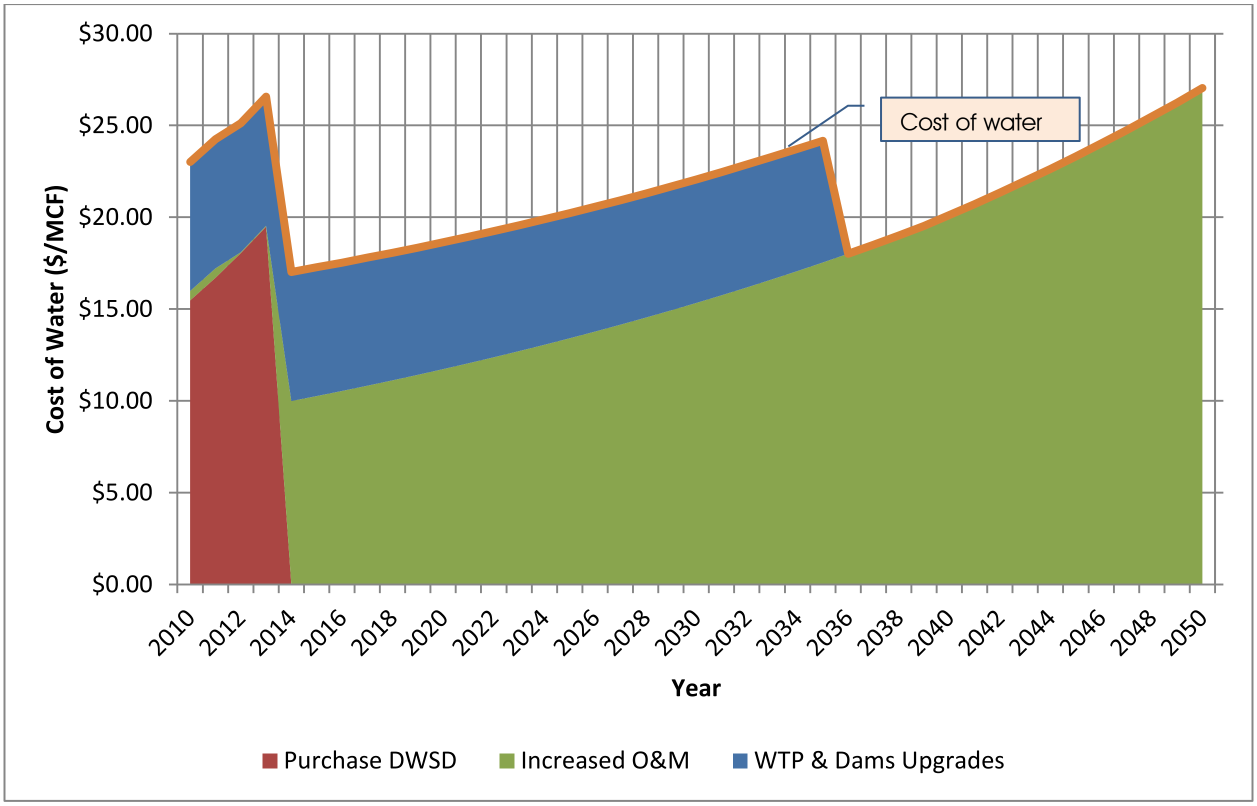
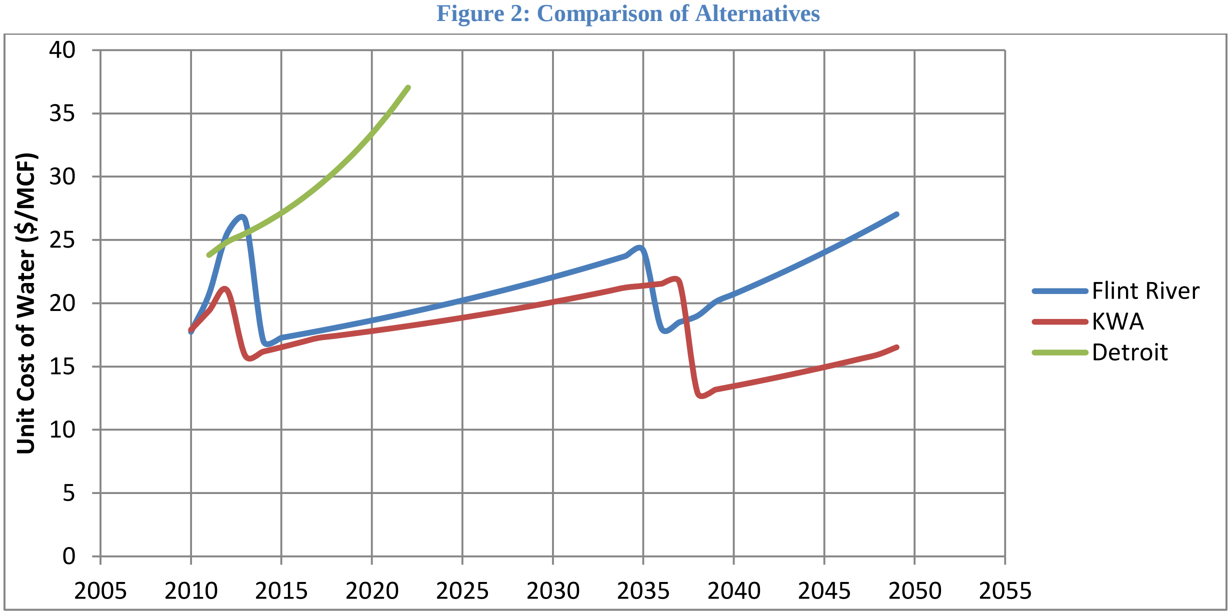


Figure 2 compares the cost of water for all three alternatives. Continued Supply by the City of Detroit results in a higher cost for water supply than the other two alternatives. The city's costs for The KWA-New Lake Huron Supply have been based upon the terms of the current KWA Raw Water Supply Contract, and the assumption that the city purchases 18 mgd capacity in the KWA system. The KWA alternative is projected to result in the lowest cost for water.

Figure 2: Comparison of Alternatives



XIII. Implementation

Planning, design, construction, and start-up will require 52 to 60 months for completion. Additional time may be required to address ancillary issues such as modifications to agreements, permits, and "non-construction related" environmental issues.

XIV. Intangibles

In addition to the upgrades identified for the dams and WTP, other issues will potentially need to be addressed if the Flint River is to be used as a water supply. Examples of these include:

- Environmental impact of work on dams or removal of sediment from the river or reservoirs
- Impact of construction and reservoir operation on the fishery
- Impact to recreational users and land owners adjacent to the Holloway Reservoir
- Potential upgrades to the city's WWTP if river flows are reduced and stricter effluent limits are included in future NPDES permits
- Impacts of the replacement of the Hamilton Dam at a lower level for improved flood control may impact the ability for the WTP to draw water from the river
- Results of a Source Water Protection Plan which may identify potential threats of contamination or other impacts to the water supply

XV. Summary

Analysis indicates that the cost of supplying water from the Flint River on a continuous basis will be greater than the proposed KWA Raw Water Supply Contract, but less than continued supplied from Detroit. Additionally, if the Flint River is to be used for a water supply for city customers, there will need to be some modifications to existing facilities, operating agreements, and permits. Upgrades will be required at the city's dams and the water treatment plant to reliably supply water to the city on a continuous basis. To meet the future maximum day demand of 18 mgd projected by city staff, one or more of the following will be required.

- Modify the Holloway Dam and Reservoir to provide additional storage
- Modify the HRMP to provide for more variance in water levels and/or modify limits on minimum discharge
- Modify the WWTP NPDES permit based on reduced flows in the river and provide resulting upgrades to WWTP for higher treatment
- Provide other raw water storage reservoirs

Addressing the preceding items is likely to require a great deal of time and effort because of the impacts on many other parties. Without making the modifications above, the river is limited to supplying a maximum day demand of about 11.6 mgd.

Appendices

1. Holloway Reservoir Management Plan
2. Excerpt of Flint WWTP NPDES permit
3. Analysis of Adequacy of Flint River as a Water Supply
4. Holloway Dam Drawings
5. 2008 Holloway Dam Safety Report
6. 2008 Utah Dam Safety Report
7. 2008 Hamilton Dam Safety Report
8. Cost of Service Study – Flint Water Treatment Plant

Appendix 1 - Holloway Reservoir Management Plan

March 13, 1987

TO: Members of the Ad Hoc Committee to Work With City of Flint Officials on Management of the Holloway Reservoir

FROM: Kenneth J. Smithee, Director
Genesee County Parks & Recreation Commission

SUBJECT: Action of the Parks & Recreation Commission

Please be advised that the recommendations as outlined on Attachment A were approved by the Genesee County Parks & Recreation Commission meeting in formal session on March 12, 1987.

On behalf of the Commission, I would like to extend our personal thanks to each of you for the assistance which you rendered which led to the agreement between the Parks & Recreation Commission and the City of Flint and will provide protection for recreational users of the Holloway Reservoir, adjacent property owners and also help protect the fish and other aquatic life.

Thanks again.

Sincerely,

Kenneth J. Smithee
Director

KJS:jp
Attachment

R-22

AGENDA ITEM: (5). i.

PRESENTED: 3/9/87

ADOPTED: 3/9/87

By the Mayor:

WHEREAS, the City of Flint in adopting ordinance 2208 granted to the Genesee County Parks and Recreation Commission the right to establish and operate park and recreational facilities and conservations programs on property owned by the City of Flint in the Holloway Reservoir area; reserving unto itself the power to control and regulate the dams and water levels of the Holloway Reservoir, and

WHEREAS, it is in the interests of the City and the Genesee County Parks and Recreation Commission to establish a Management Plan which optimizes the summer recreational programs available to the public while preserving downstream usages of the Flint River, and which will assist the City in implementing the provisions of ordinance 2208.

NOW, THEREFORE, BE IT RESOLVED, that the City of Flint adopts the attached Holloway Reservoir Management Plan.

APPROVED AS TO FORM:

Chief Legal Officer

R990

HOLLOWAY RESERVOIR MANAGEMENT PLAN

GENERAL OBJECTIVE:

To operate Holloway Dam in a manner that optimizes summer recreation on the Holloway Reservoir while preserving downstream usages of the waters of the Flint River and assuring availability of a back-up water supply for Flint.

GENERAL OPERATING PROCEDURE:

Spring Fill - The City of Flint shall operate the dam with the intention of capturing a sufficient quantity of spring run-off to maintain the reservoir at a minimum elevation of 755 feet no later than May 1 of each year.

Summer Operation - The City of Flint shall maintain a minimum outflow of 65 cfs until the level of the reservoir falls to an elevation of 752.7 feet. At any time that the level reaches elevation 752.7 feet the city shall operate the dam such that the outflow does not exceed inflow, on any given day, provided, however, that the city shall not be obligated to make more than one adjustment to flow during any given day.

Winter Drawdown - The City of Flint shall operate the dam to gradually drawdown the reservoir during the first two weeks of November to an elevation of 751 feet in order to prevent structural damage to the dam from freezing.

Notification - The City of Flint shall provide prior notification to the Genesee County Parks and Recreation Commission before making a change in dam operations which result in significant drawdown.

Maintenance and Construction - Routine maintenance shall be scheduled to avoid conflicts with major events and peak usage periods on the reservoir. A minimum of 30 days notification shall precede all maintenance and construction involving significant drawdown. The Genesee County Parks and Recreation Commission shall promptly receive copies of all dam maintenance permit applications made by the City of Flint to the Michigan Department of Natural Resources.

Gauging of Water Flow into Reservoir - The City of Flint shall be a cooperator with the U.S.G.S. and State of Michigan to establish a stream gauge on the north branch of the Flint River upstream of the Holloway Reservoir and be a cooperator on the annual maintenance and operation of the existing gauge on the south branch of the Flint River and the new gauge on the north branch of the Flint River.

EMERGENCIES:

In emergency situations affecting public health, safety and welfare the City of Flint shall operate the Holloway dam in a manner to protect the public health, safety and welfare. This shall be done even though recreational users and others may be temporarily inconvenienced. Situations which shall be identified as emergencies shall include but not be limited to the following: flood conditions, interruption of the City of Flint's public water supply, and event(s) which threatens the structural integrity of the dam, and acts of God. However, low flow augmentation for sewage treatment shall not be considered as an emergency.

MONITORING:

The City of Flint in cooperation with the Genesee County Parks and Recreation Commission will assure conformance with the Holloway Reservoir Management Guidelines. A standing oversight committee shall be created to provide monitoring of the reservoir management and facilitate exchange of timely information regarding the Holloway dam and reservoir. The committee shall be composed of two members from both the City of Flint and the Genesee County Parks and Recreation Commission and shall meet in April and November of each year. The Genesee County Parks and Recreation Commission shall provide the City of Flint with a schedule for summer events on Holloway Reservoir at the April meeting of the Oversight Committee.

PERIOD AND EXECUTION OF AGREEMENT:

The Holloway Reservoir Management Plan shall be in full force and effect when officially adopted by the Flint City Council and the Genesee County Parks and Recreation Commission and shall remain so until altered by mutual agreement.

MANAGEMENT PLAN STATUS:

This management plan establishes targets for optimal operation of the Holloway Dam and Reservoir but does not replace the terms and conditions of Flint City Ordinance No. 2208.

p:DAM(a)

Appendix 2 - Excerpt of Flint WWTP NPDES permit

PART I

Section A. Limitations and Monitoring Requirements

1. Final Effluent Limitations, Monitoring Point 001A

During the period beginning on the effective date of this permit and lasting until the expiration date of this permit, the permittee is authorized to discharge treated municipal wastewater from Monitoring Point 001A through Outfall 001. Outfall 001 discharges to the Flint River. Such discharge shall be limited and monitored by the permittee as specified below.

	Maximum Limits for Quantity or Loading				Maximum Limits for Quality or Concentration					
Parameter	**Monthly**	**7-Day**	**Daily**	**Units**	**Monthly**	**7-Day**	**Daily**	**Units**	**Frequency of Analysis**	**Sample Type**
Flow	(report)	---	(report)	MGD	---	---	---	---	Daily	Report Total Daily Flow
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)										
4/1-4/30	6,672	10,000	---	lbs/day	16	---	24	mg/l	Daily	24-Hr Composite
5/1-10/31	2,920	3,750	---	lbs/day	7	---	9	mg/l	Daily	24-Hr Composite
11/1-11/30	4,590	6,672	---	lbs/day	11	---	16	mg/l	Daily	24-Hr Composite
12/1-3/31	5,420	8,340	---	lbs/day	13	---	20	mg/l	Daily	24-Hr Composite
Total Suspended Solids										
5/1-10/31	8,340	12,500	---	lbs/day	20	30	---	mg/l	Daily	24-Hr Composite
11/1-/4/30	12,500	18,800	---	lbs/day	30	45	---	mg/l	Daily	24-Hr Composite
Ammonia Nitrogen (as N)										
4/1-4/30	2,920	4,170	---	lbs/day	7.0	---	10.0	mg/l	Daily	24-Hr Composite
5/1-10/31	667	1,460	---	lbs/day	1.6	---	3.5	mg/l	Daily	24-Hr Composite
11/1-11/30	2,080	2,920	---	lbs/day	5.0	---	7.0	mg/l	Daily	24-Hr Composite
12/1-3/31	2,500	3,128	---	lbs/day	6.0	---	7.5	mg/l	Daily	24-Hr Composite
Total Phosphorus (as P)	417	---	---	lbs/day	1.0	---	---	mg/l	Daily	24-Hr Composite
Fecal Coliform Bacteria	---	---	---	---	200	400	---	cts/100 ml	Daily	Grab
Total Residual Chlorine	---	---	---	---	---	---	0.038	mg/l	Daily	Grab
Total Mercury										
Through 12/31/2008	---	---	---	lbs/day	(report)	---	---	ng/l	Quarterly	Grab
Beginning 1/1/2009	0.0042	---	---	lbs/day	10	---	---	ng/l	Quarterly	Grab
Acute Toxicity										
Through 12/31/2008	---	---	---	---	---	---	(report)	TU_A	Quarterly	24-Hr Composite
Beginning 1/1/2009	---	---	---	---	---	---	1.0	TU_A	Quarterly	24-Hr Composite
Chronic Toxicity										
Through 12/31/2008	---	---	---	---	(report)	---	---	TU_C	Quarterly	24-Hr Composite
Beginning 1/1/2009	---	---	---	---	1.5	---	---	TU_C	Quarterly	24-Hr Composite
					Minimum Daily		**Maximum Daily**			
pH	---	---	---	---	6.5	---	9.0	S.U.	Daily	Grab

The following design flow was used in determining the above limitations, but is not to be considered a limitation or actual capacity: A rated design capacity of 50 MGD and the 1988 Water Resources Commission directive to use a 95 percent exceedance (Flint River drought) flow of 85 cfs (Holloway Reservoir Management Plan) for limit calculations.

Appendix 3 - Analysis of Adequacy of Flint River as a Water Supply

Technical Memorandum
Analysis of Adequacy of Flint River as Water Supply

1.0 Quantity of Water Required

Recommended Standards for Water Works, 2003 Edition indicates that the quantity of surface water at the source shall:

- Be adequate to meet the maximum projected water demand of the service area as shown by calculations based on a one in fifty year drought or the extreme drought of record, and should include consideration of multiple year droughts. Requirements for flows downstream of the intake shall comply with requirements of the appropriate reviewing authority.
- Provide reasonable surplus for anticipated growth
- Be adequate to compensate for all losses such as silting, evaporation, seepage, etc.
- Be adequate to provide ample water for other legal users of the source.

2.0 Demand Summary

City staff has indicated the future maximum day demand of the city is 18 mgd.

In addition to the water used by customers, some water will be required for water treatment processes and filter backwash. An allowance for WTP Backwash and Process water of 2 mgd is assumed.

Water used for fire-fighting is not included in customer demand or sales. An allowance 0.7mgd for replenishing water used for fire-fighting is assumed.

The maximum day demand represents the quantity of water which must be supplied on the particular day that the highest use (demand) occurs. Treatment and pumping must be designed to deliver the maximum day demand. During peak periods, storage from the Holloway Reservoir can be utilized to supplement the natural river flow. For analysis of the river as a source, the maximum month will be used as the demand.

A review of the city's water demands and precipitation records suggest that maximum month demand is about 80% of the maximum day demand.

The maximum sustained demand to be withdrawn from the river is computed in the following table:

Table 1: City of Flint Design Demand Summary

Future Maximum Day Demand (Customers)		18.0 mgd
Future Maximum Day Demand (WTP Backwash / Process Water)		2.0 mgd
Subtotal (Future Maximum Day Demand)		20.0 mgd
Sustained (30 day) Future Maximum Day Demand	(80% of MDD)	16.0 mgd
Replenish Water from Fire Fighting		0.7 mgd
Future Maximum Day Demand (Source Water)		16.7 mgd

3.0 Additional Demands and Requirements

In addition to the demands from Section 2, the following demands must be accounted for:

3.1 Mutual Aid

The City and GCDC-WWS have a mutual aid agreement to supply each other water in the event of a disruption in supply or other emergency. The agreement provides that the city will supply GCDC-WWS up to 8 mgd.

For this analysis, it is assumed that an emergency will be corrected within 14 days. The volume of water that may be required is therefore: 14 days * 8,000,000 gal/day = 112,000,000 gal. This volume will be reserved from the reservoir volume.

3.2 Evaporation

Both the Holloway and Mott dams have been constructed since the drought period of the 1930's, which is being used as the base river flow for analysis. Evaporation from the Holloway Reservoir and Mott Lake will reduce the amount of available from the river. The NWS publishes an atlas which shows evaporation rates. Evaporation is primarily a factor during the "growing season"; the atlas shows that about 24" of water is lost via evaporation from open water surfaces in Genesee County over the May through October period. Loss by evaporation will be offset by the addition of rainfall directly upon the water surface. Since the analysis is based upon drought conditions, the low rainfall having a recurrence rate of 100 years will be used. During the May through October period, 11.5 inches of rain is estimated during the 1 in 100 dry year. The net loss by evaporation is therefore 12.5 inches.

The following table summarizes the loss by evaporation, over the six month period from May through October.

Table 2: Reservoir Evaporation Loss

Reservoir	Surface Area (Acres)	Evaporation (inches)	Precipitation (inches)	Net Loss by Evaporation (Gallons)
Holloway Reservoir	1,973	24	11.5	669,646,065
Mott Lake	684	24	11.5	232,153,020
Total				901,799,085

3.3 Siltation

The July 2001 Flint River Assessment completed by the MDNR indicates that sedimentation occurs in the Holloway Reservoir at an accelerated rate, but does not provide quantities. Measurements of the silt accumulation in the reservoir have not been completed. Accumulations of several feet have occurred in other reservoirs. Sedimentation of an average of 1 foot across the Holloway Reservoir will result in the loss of 643,000,000 gallons of storage, or about ten percent of the total volume available.

Mott Lake is not used as a water storage reservoir. Its level is controlled by a fixed weir. Although siltation likely occurs in Mott Lake too, it has no impact on storage for water supply.

3.4 Seepage

Seepage is not believed to have a significant impact on the availability of water at the WTP. Seepage through the embankments of either the Holloway or Mott dams or through the bottom of the reservoirs seems likely to migrate back to the Flint River, although perhaps downstream of the reservoirs, prior to the WTP.

3.5 Flint WWTP

The City's WWTP discharges treated wastewater to the Flint River. The NPDES permit issued to the WWTP has established limits for the treated effluent, based on a drought flow in the river of at least 85 cfs.

3.6 Holloway Reservoir Management Plan

In 1977 the City and Genesee County executed the Holloway Reservoir Management Plan (HRMP) which established parameters for the operation of the dam and reservoir. In 1977, water was no longer withdrawn from the river for water supply and the HRMP appears to have been developed to address four primary issues:

- Availability to utilize the reservoir for water supply as a backup or alternative supply
- Provide for physical maintenance of the dam
- Provide for the recreational use of the reservoir
- Provide flow augmentation to Flint WWTP

The HRMP establishes a summer operating level of 755 and a winter level 751. The summer level maximizes the volume of water available during the dry period in the event that the river is to be used as a water supply. The higher level also supports recreational activities on the reservoir. The 751 winter level provides protection against damage from freezing during the winter. The HRMP establishes a minimum discharge of 65 cfs from the dam, presumably to provide a minimum flow of 85 cfs in the river at the WWTP.

4.0 Analysis

It is assumed that the demands and other requirements identified above are to be maintained in the event that water is withdrawn from the Flint River for water supply. In 1963, USGS published Water Resources Flint Area Michigan, which includes an analysis of the river as a water supply. This publication includes design information regarding the Holloway Reservoir and its operation for water supply.

In 1977 when the HRMP was executed, water was not withdrawn from the river for water supply. If the HRMP required a minimum discharge of 65 cfs at the Holloway Dam to provide for adequate flow in the river at the WWTP, the minimum discharge from the Holloway Dam should be increased by the amount of water withdrawn for water supply if the current river flow at the WWTP is to be maintained.

65 cfs + 16.7 mgd (25.8 cfs) = 90.8 cfs (58.7 mgd)

Figure 1 shows the sustained discharge which can be maintained from the Holloway Reservoir during a drought period. This graph is based on USGS records of flow in the river between 1930 and 1952. This period includes the drought period of 1930 to 1937, which is USGS considers the most severe drought in Michigan history, having a recurrence period of 1 every 50 to 70 years. This period was prior to the construction of Holloway Dam, so river records reflect the natural flow of the river without impact by dam operations.

Figure 1: Draft-Storage Curve, Flint River near Otisville (excerpt from USGS Water Resources Flint Area Michigan)

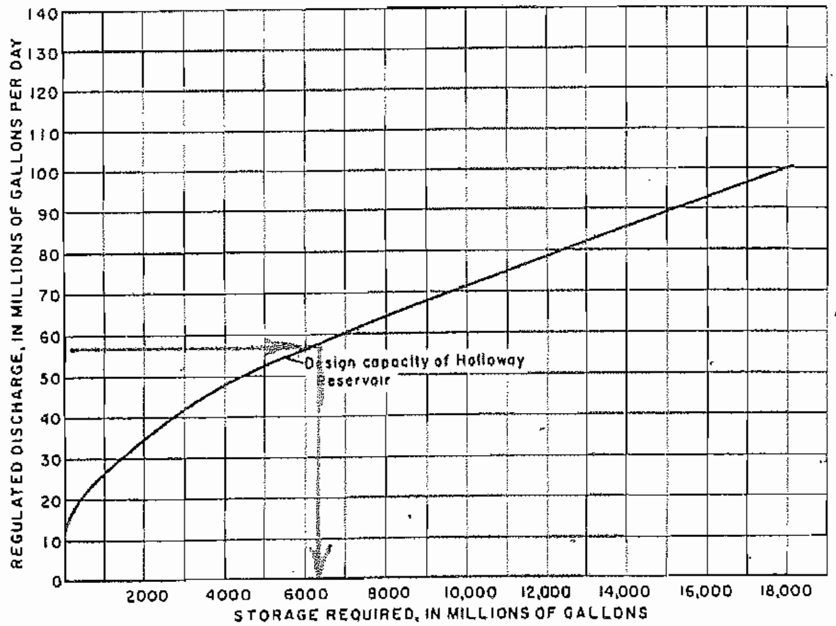


Figure 1 indicates that about 6.2 billion gallons of storage is needed to maintain a sustained discharge of 58.6 mgd from the reservoir to provide the minimum river flow of 85 cfs at the WWTP.

In addition to the 6.2 billion gallons of storage, additional storage is required to provide GCDC-WWS an emergency supply and to make up for reservoir loss by evaporation.

Table 3: Storage Requirements to Maintain Current Conditions plus Water Supply

Storage to meet sustained demand and WWTP flow:	6.20	billion gallons
Storage to provide backup supply to GCDC-WWS:	0.11	billion gallons
Storage to make up loss by evaporation:	0.90	billion gallons
Storage lost by siltation:	0.64	billion gallons (assumed)
Storage to provide loss by seepage:	0.00	billion gallons (assumed)
Storage Needed to Supplement River Flow:	7.85	billion gallons

For this analysis, it is assumed that storage is available from the Holloway Reservoir to supplement the natural river flow.

- The Holloway Reservoir was designed to provide storage for water supply in the 1950's
- The Mott Dam is a fixed weir, so storage is not available. The dam is owned by the Genesee county Parks Department and provides recreational benefit.
- The Hamilton Dam impoundment is limited to the river channel; storage volume is negligible.
- The Utah Dam is inoperable.

- The Kearsley Dam is not directly located on the Flint River, but on the Kearsley Creek just prior to its confluence with the Flint River. The Kearsley Creek discharges to the Flint River downstream of the City's WTP so storage from the river is not available for water supply; however, discharge from the Kearsley dam can be used to supplement downstream river flows, including the flow in the river at the WWTP. The Kearsley Reservoir can provide a maximum of 650 million gallons of storage.
- The Thread Lake Dam is not located on the Flint River, but the Thread Creek discharges into the Swartz Creek which discharges into the Flint River just west of the downtown area. The Thread Lake dam provides a maximum storage volume of 100 million gallons of storage. Discharge from the Thread Lake dam could be used to supplement downstream river flows, but not for water supply.
- For this analysis, storage from neither the Kearsley Reservoir nor Thread Lake is included. Both dams were constructed prior the Holloway Reservoir and discharges from the Kearsley Dam and Thread Lake Dam are assumed to be included in the analysis presented in the USGS publication.

Following is a capacity curve for the Holloway Reservoir, from the USGS Water Resources Flint Area.

Figure 2: Holloway Reservoir Storage Capacity (excerpt from USGS Water Resources Flint Area Michigan)

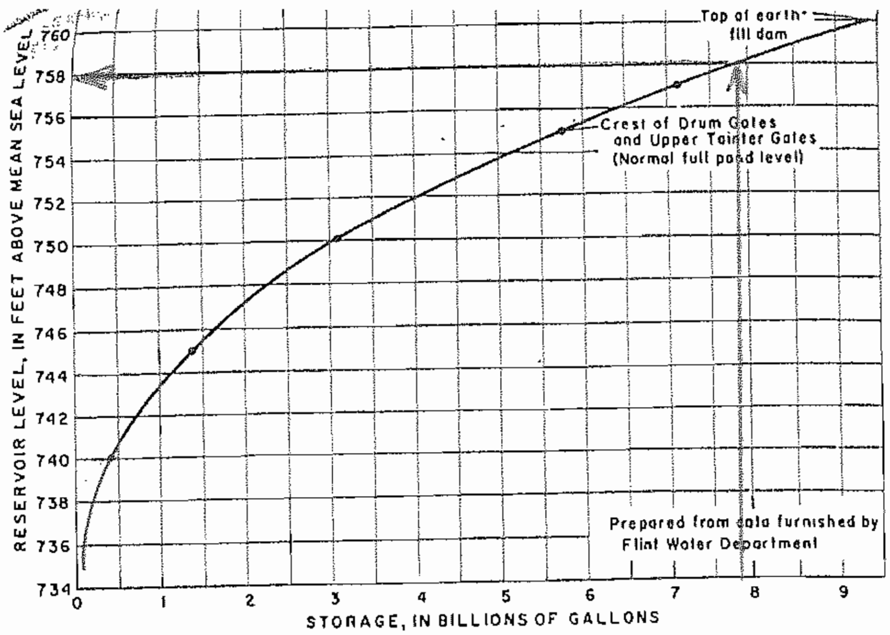


Figure 2 indicates that a Holloway Reservoir level of 758.0 feet provides storage of 7.85 billion gallons.

Review of design drawings of the Holloway Dam indicates that the dam was designed to use drum gates to maintain the normal water level(s) of the reservoir. The drum gates can rotate to allow for reservoir levels ranging from a low level of 751 feet to a high level of 755 feet. If the reservoir is to be maintained

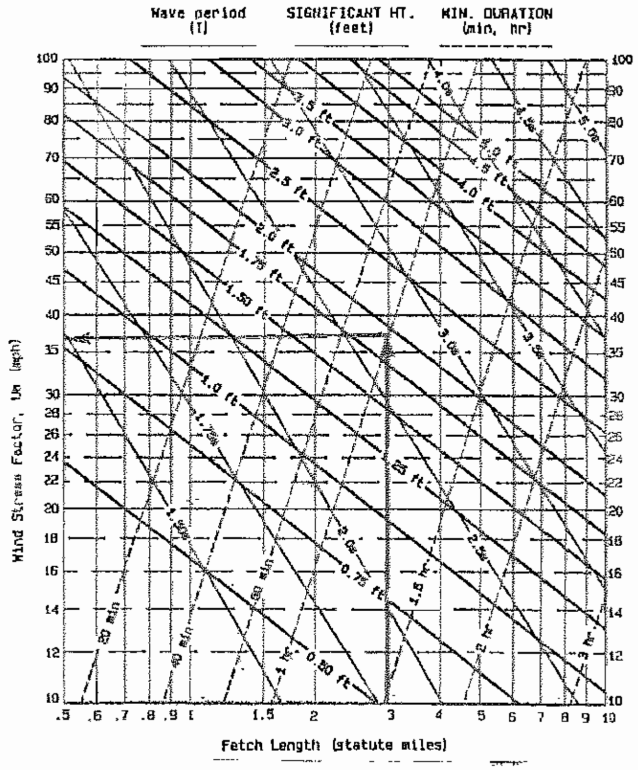
at a higher level than the current summer level of 755 feet, modifications will be required to the drum gates.

According to the original dam design drawings, the dam embankment was constructed to elevation 763 feet (however, the USGS reports shows the top elevation as 760 feet). If the reservoir level is raised to 758 feet, only about five feet of freeboard will be provided to guard against overtopping. There are three concerns regarding increasing the reservoir level from 755 to 758 feet.

The increased hydraulic pressure resulting from the higher water level on one side of the dam will result in increased seepage through the embankment, and a reduction in its integrity.

The reservoir has a fetch of about three miles east from the dam. Figure 3 shows that a 37 mph wind sustained for one hour duration from the east can result in waves capable of two feet. The original design drawings show rip-rap armoring on the reservoir side of the dam embankment to an elevation of 757 feet. Rip-rap armoring should be extended to at least two feet higher than the 758 feet level to protect against wave action.

Figure 3: Predicted Wave Action – Holloway Reservoir



The reservoir is tributary to a large watershed. There have been rapid increases in river flow (and reservoir level) soon after intense rain events in the watershed. A rain storm in June 1996 resulted in a 1.62 foot increase in the water level of the reservoir resulting in the opening of dam gates and discharge of 7,740 cfs. Reducing the freeboard also reduces the volume available for flood management.

5.0 Quantity of Water Supply Available

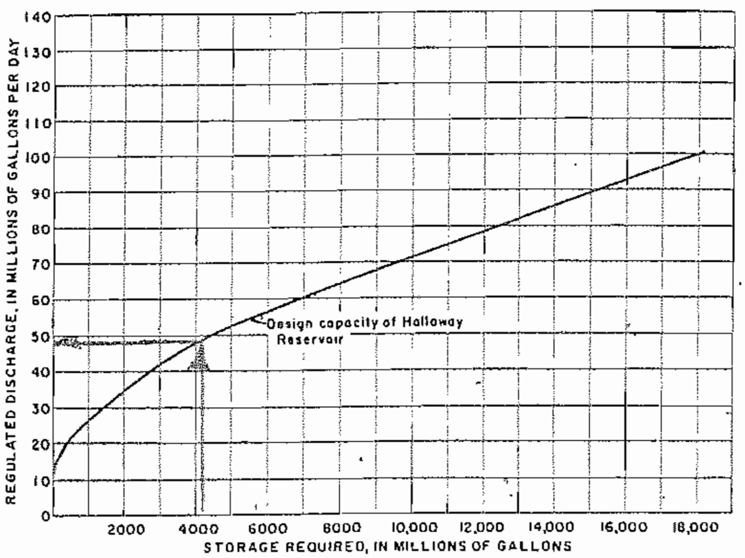
Analysis has shown that without modifications to facilities and/or permits and agreements, the river cannot supply the future maximum demand of the city.

Table 4: Storage Available for Water Supply

Original Storage Volume of Holloway Reservoir (elevation 755')	5.76	billion gallons
Storage lost by Sedimentation (assumed)	0.64	billion gallons
Storage to make up for Evaporation	0.9	billion gallons
Storage to provide backup supply for GCDC-WWS	0.11	billion gallons
Storage available to supplement river flow	4.11	billion gallons

The following figure shows that 4.11 billion gallons of storage can sustain a supplemental flow of 48 mgd.

Figure 4 – Sustained Discharge Available from Holloway Reservoir



A minimum discharge of 48 cfs from the Holloway Reservoir can support a sustained water withdrawal of about 11 mgd and maintain 85 cfs at the WWTP, as shown in the following table.

Table 5 – Maximum Sustained WTP Withdrawal Available

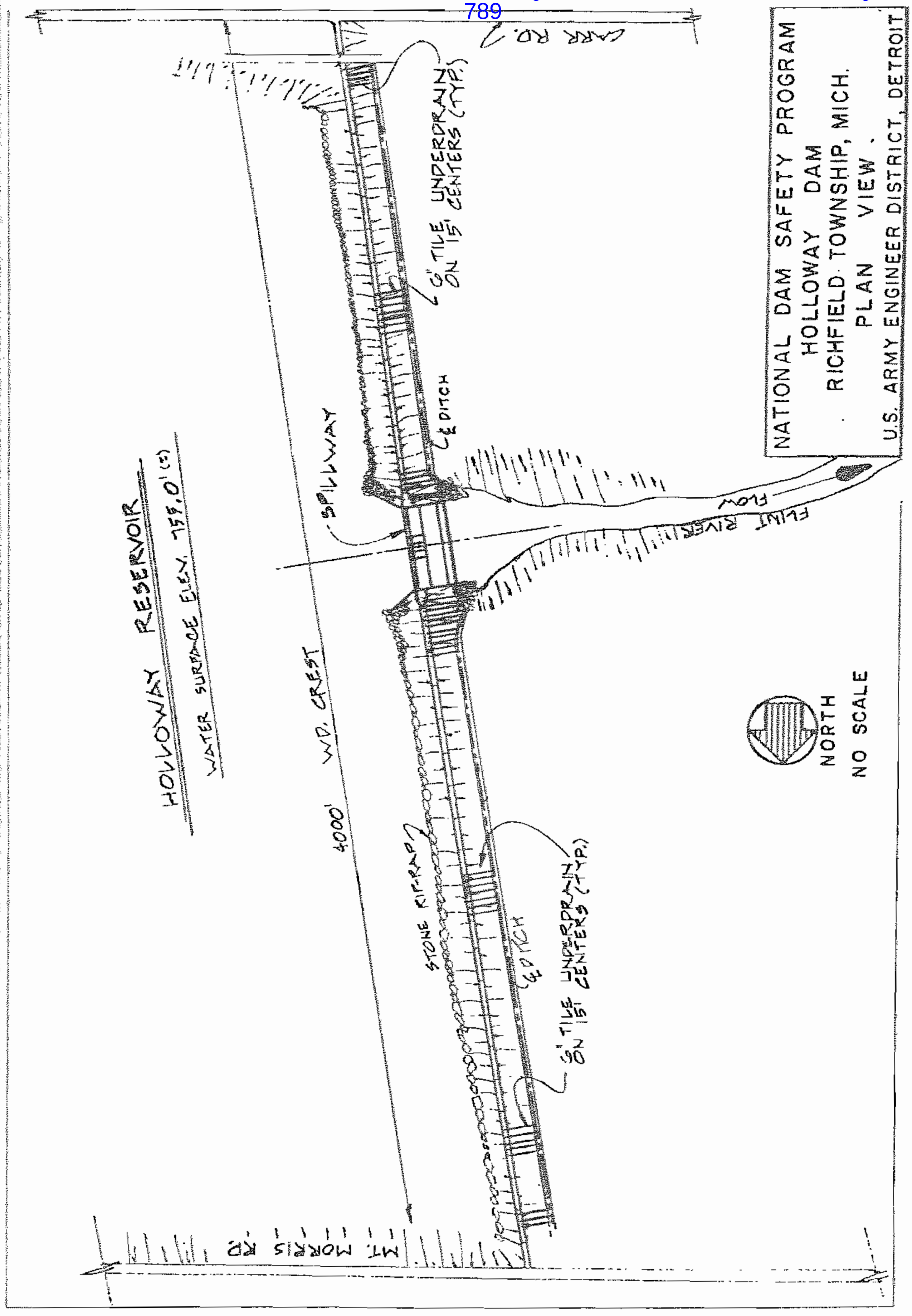
	1978 - Holloway Reservoir Management Plan	Future
Minimum Reservoir Discharge	65 cfs	48 cfs
River Inflow	20 cfs	20 cfs
WTP Withdrawal	0 cfs	17 cfs (10.99 Mgd)
River Flow at WWTP	85 cfs	85 cfs

A sustained water withdrawal of 11 mgd will support a maximum day demand of 11.6 mgd, as shown in the following table.

Table 6 – Available WTP Maximum Day Demand

Sustained Withdrawal Available		11.0 mgd
Water to replenish fire fighting		0.7 mgd
Sustained (30 day) Future Maximum Day Demand Available		10.3 mgd
Future Maximum Day Demand Available	(Multiply by 125%)	12.9 mgd
Water available for WTP Backwash/Process		1.3 mgd
Water available for customer Max Day Demand		11.6 mgd

Appendix 4 - Holloway Dam Drawings



NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
PLAN VIEW.
U.S. ARMY ENGINEER DISTRICT, DETROIT
HOLLOWAY RESERVOIR
WATER SURFACE ELEV. 755.0' (±)
4000' W.D. CREST
SPILLWAY
6" TILE UNDERDRAIN ON 15' CENTERS (TYP.)
℄ DITCH
STONE RIP-RAP
℄ DITCH
6" TILE UNDERDRAIN ON 15' CENTERS (TYP.)
FLINT RIVER
FLOW
CARR RD.
MT. MORRIS RD.
NORTH
NO SCALE

FIGURE No. 5

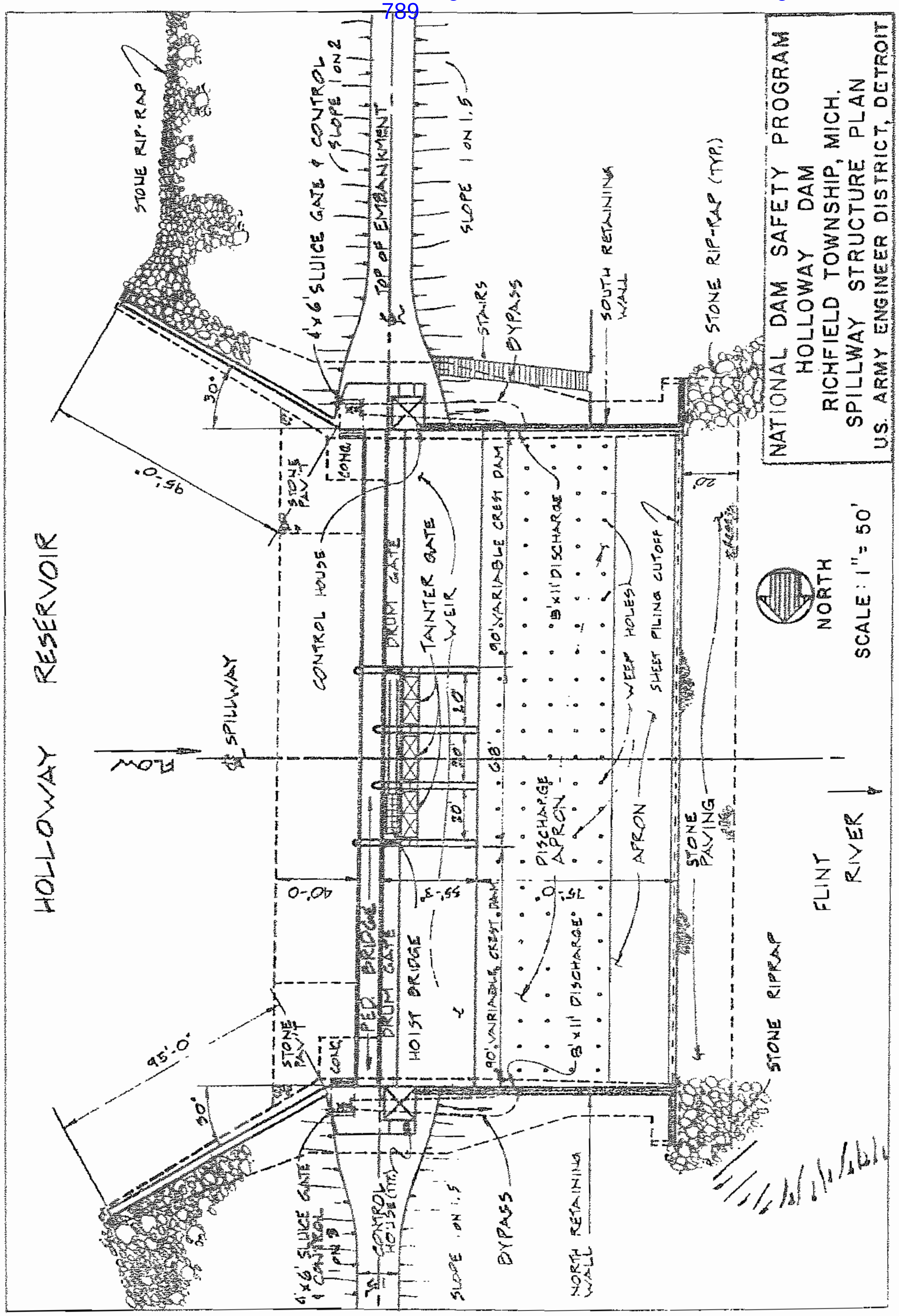

NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
SPILLWAY STRUCTURE PLAN
U.S. ARMY ENGINEER DISTRICT, DETROIT
HOLLOWAY RESERVOIR
FLOW
℄ SPILLWAY
FLINT RIVER
NORTH
SCALE: 1" = 50'
STONE RIP-RAP
4'x6' SLUICE GATE & CONTROL
SLOPE 1 ON 2
℄ TOP OF EMBANKMENT
SLOPE 1 ON 1.5
STAIRS
BYPASS
SOUTH RETAINING WALL
STONE RIP-RAP (TYP.)
30°
95'-0"
STONE PAV'T
CONC
CONTROL HOUSE
DRUM GATE
TAINTER GATE
WEIR
90' VARIABLE CREST DAM
8'x11' DISCHARGE
WEEP HOLES
SHEET PILING CUTOFF
DISCHARGE APRON
APRON
STONE PAVING
40'-0
55'-3"
75'-0"
PED. BRIDGE
DRUM GATE
HOIST BRIDGE
90' VARIABLE CREST DAM
8'x11' DISCHARGE
STONE RIPRAP
4'x6' SLUICE GATE & CONTROL
CONTROL HOUSE
SLOPE 1 ON 1.5
BYPASS
NORTH RETAINING WALL

FIGURE No. 6

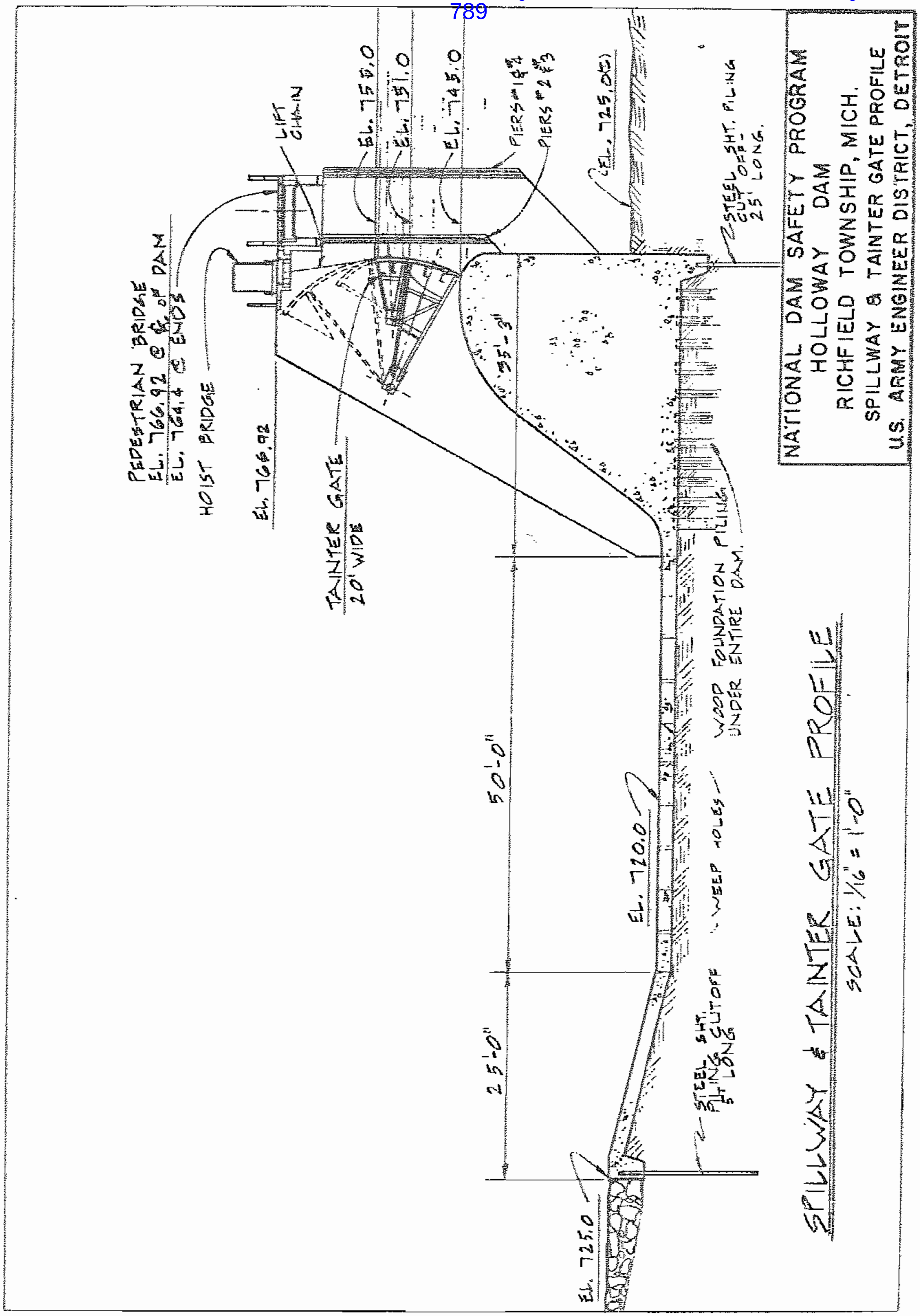

NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
SPILLWAY & TAINTER GATE PROFILE
U.S. ARMY ENGINEER DISTRICT, DETROIT
PEDESTRIAN BRIDGE
EL. 766.92 @ ℄ of DAM
EL. 764.4 @ ENDS
HOIST BRIDGE
EL. 766.92
TAINTER GATE
20' WIDE
LIFT CHAIN
EL. 755.0
EL. 751.0
EL. 745.0
PIERS #1 & 4
PIERS #2 & 3
EL. 725.0(?)
STEEL SHT. PILING CUT OFF - 25' LONG.
35'-3"
WOOD FOUNDATION PILING UNDER ENTIRE DAM.
50'-0"
EL. 720.0
WEEP HOLES
25'-0"
STEEL SHT. PILING CUTOFF 5' LONG
EL. 725.0
SPILLWAY & TAINTER GATE PROFILE
SCALE: 1/16" = 1'-0"

FIGURE No.7

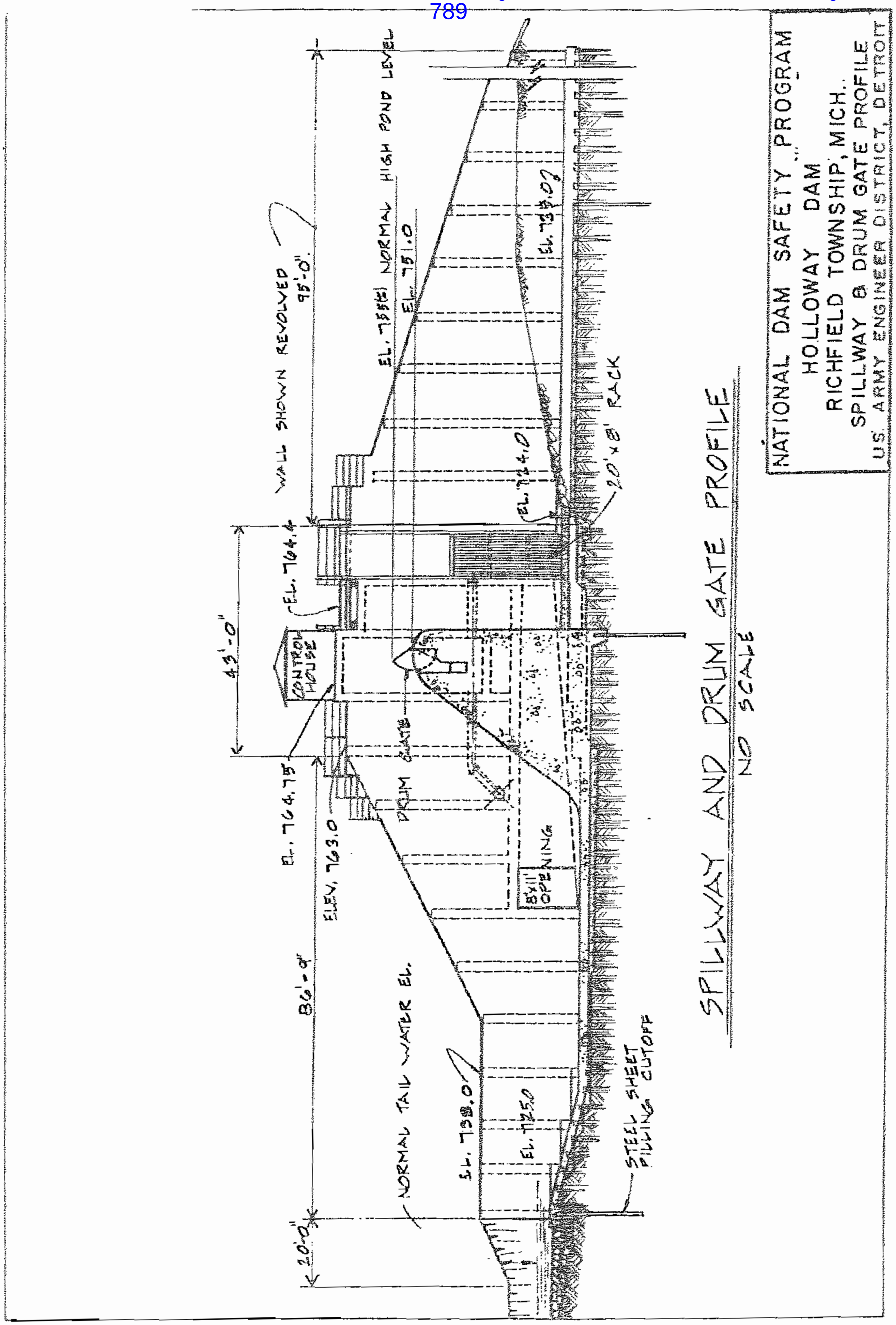
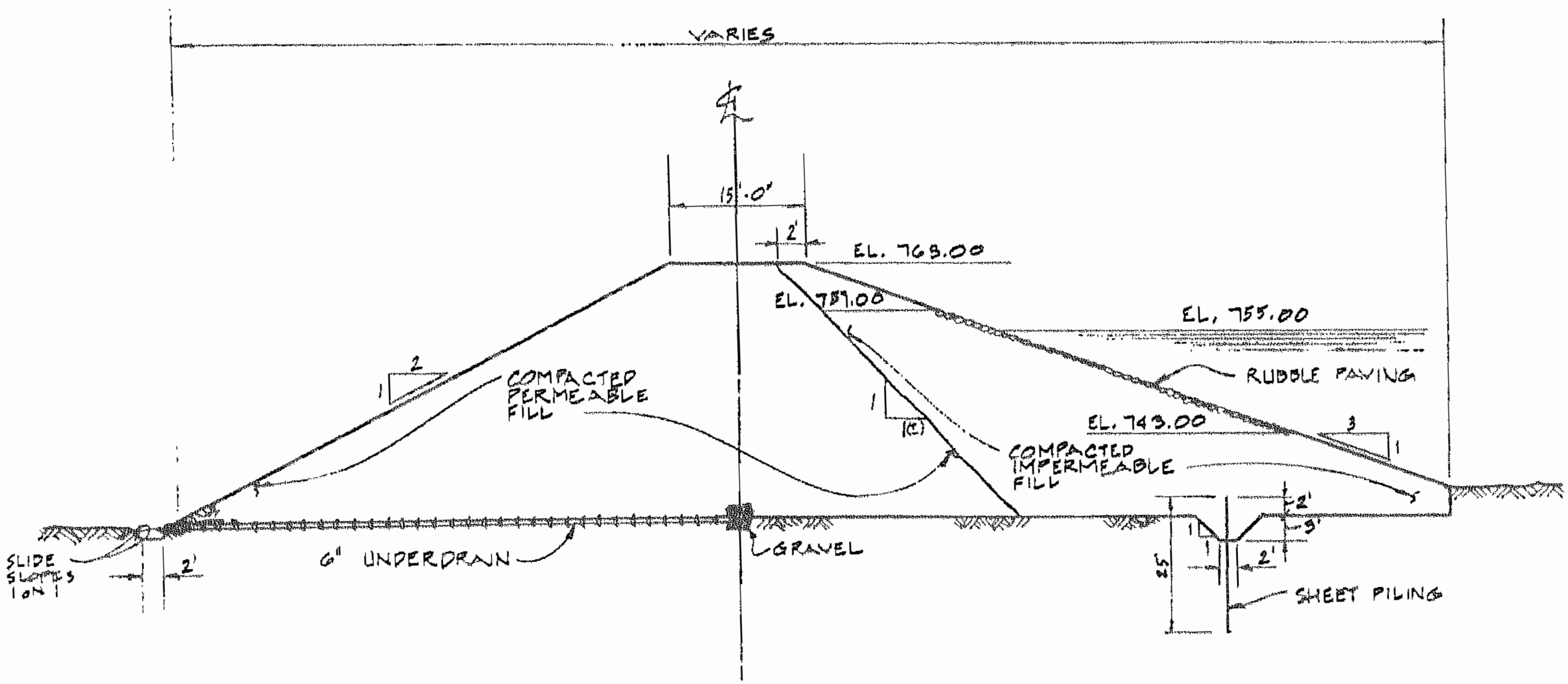

NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
SPILLWAY & DRUM GATE PROFILE
U.S. ARMY ENGINEER DISTRICT, DETROIT
SPILLWAY AND DRUM GATE PROFILE
NO SCALE
WALL SHOWN REVOLVED
95'-0"
EL. 755(±) NORMAL HIGH POND LEVEL
EL. 751.0
EL. 738.0
EL. 724.0
20'x8' RACK
EL. 764.4
43'-0"
CONTROL HOUSE
DRUM GATE
EL. 764.75
ELEV. 763.0
8'x11' OPENING
86'-9"
NORMAL TAIL WATER EL.
EL. 738.0
EL. 725.0
STEEL SHEET PILLING CUTOFF
20'-0"

FIGURE No. 8



TYPICAL DAM SECTION

NO SCALE

NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
EARTH EMBANKMENT PROFILE
U.S. ARMY ENGINEER DISTRICT, DETROIT

FIGURE No.9

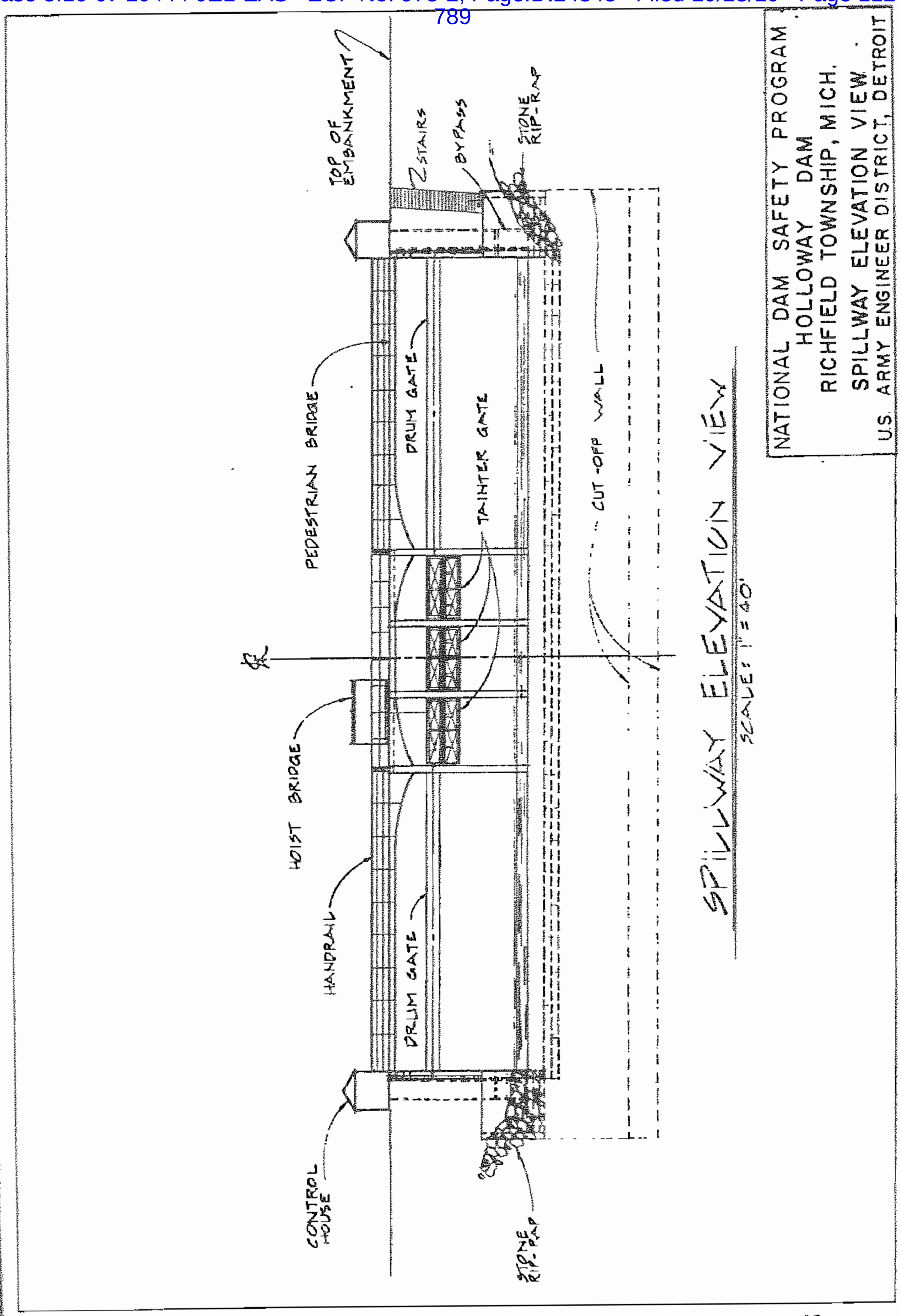
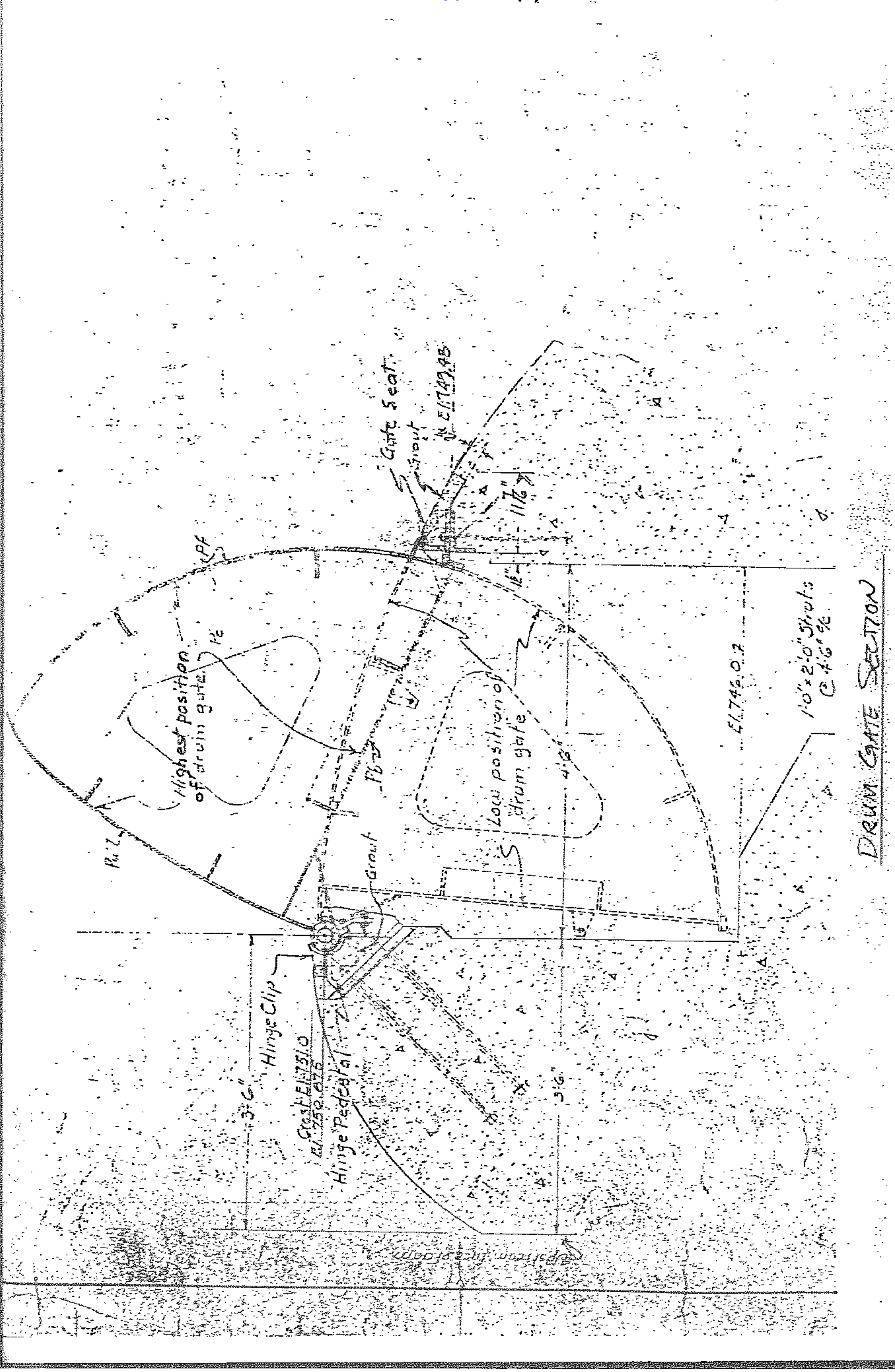
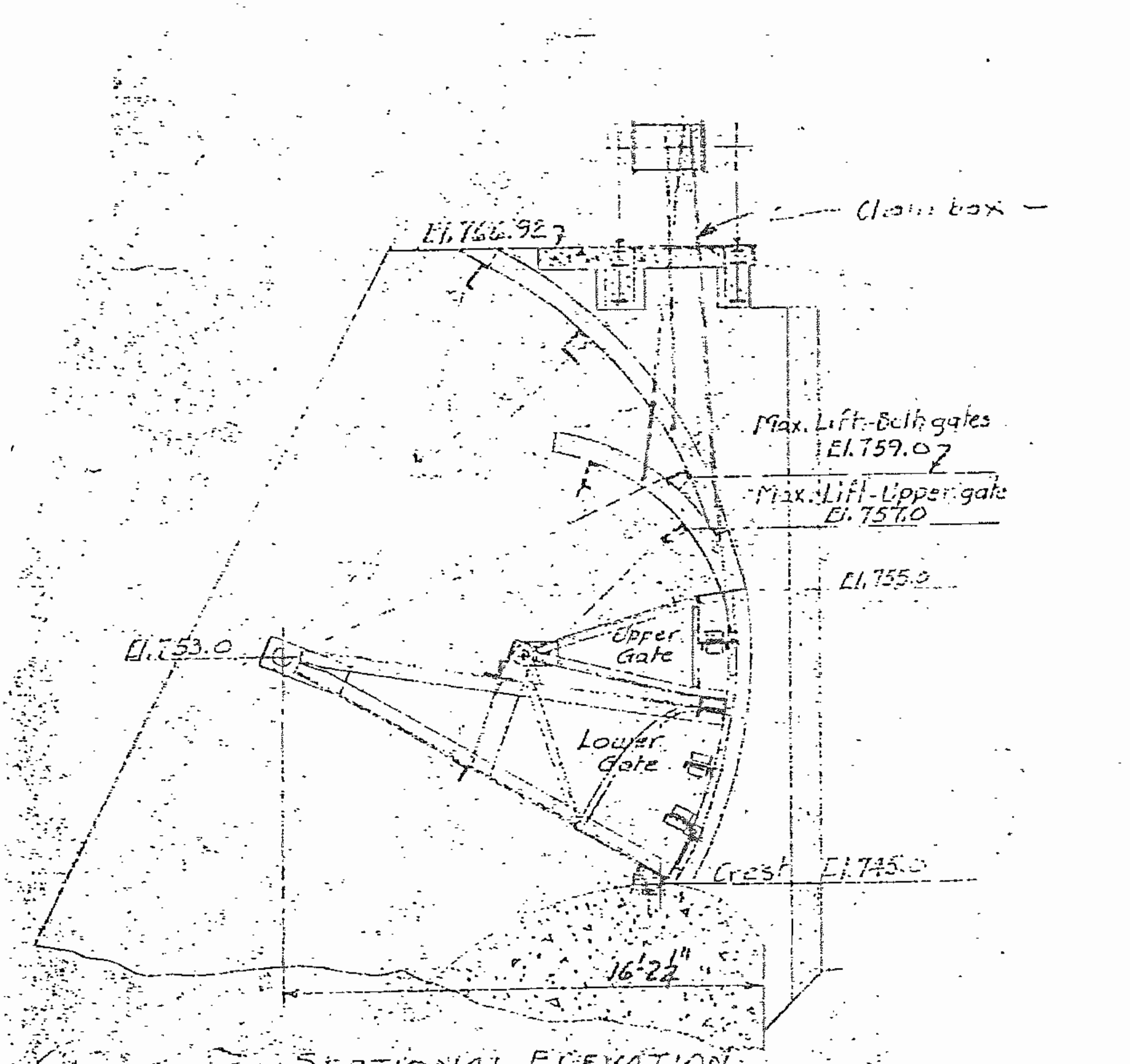

NATIONAL DAM SAFETY PROGRAM
HOLLOWAY DAM
RICHFIELD TOWNSHIP, MICH.
SPILLWAY ELEVATION VIEW
U.S. ARMY ENGINEER DISTRICT, DETROIT
SPILLWAY ELEVATION VIEW
SCALE: 1" = 40'
TOP OF EMBANKMENT
STAIRS
BYPASS
STONE RIP-RAP
PEDESTRIAN BRIDGE
DRUM GATE
TAINTER GATE
CUT-OFF WALL
HOIST BRIDGE
HANDRAIL
DRUM GATE
CONTROL HOUSE
STONE RIP-RAP

FIGURE No. 10


DRUM GATE SECTION
Highest position of drum gate
Low position of drum gate
Gate Seat
Grout
Grout
Hinge Clip
Hinge Pedestal
1'0"×2'0" Struts
3'-6"
3'-6"



SECTIONAL ELEVATION OF TAINTER GATE.

Appendix 5 - 2008 Holloway Dam Safety Report

MICHIGAN PUBLIC ACT 451, PART 315
INSPECTION REPORT
HOLLOWAY DAM
GENESEE COUNTY, MICHIGAN
INVENTORY NUMBER 064 – HIGH HAZARD

FOR

CITY OF FLINT
WATER TREATMENT PLANT
4500 N. DORT HIGHWAY
FLINT, MICHIGAN 48505
ATTN: MR BRENT WRIGHT
(810) 787-6537

BY

Stantec Consulting Michigan Inc.
Engineers – Planners – Surveyors
3959 Research Park Drive
Ann Arbor, Michigan 48108-2219
(734) 761-1010

STATE of MICHIGAN
DANA M. DOUGHERTY
ENGINEER
NO.
24737
REGISTERED PROFESSIONAL ENGINEER

INSPECTOR(S): Dana M. Dougherty – Stantec Consulting Michigan Inc.

DATE OF INSPECTION: October 19, 2008

PROFESSIONAL ENGINEER: Dana M. Dougherty, PE
STANTEC CONSULTING MICHIGAN INC.
3959 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48108-2219

Dana M. Dougherty

Dana M. Dougherty, PE #24737

HOLLOWAY DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

Table of Contents

LIST OF APPENDICES

1.0 Purpose and Authority

The purpose of the report is to present a summary of findings for the field inspection of the Holloway Dam completed by Stantec Consulting Michigan Inc. (Stantec) on October 19, 2008 pursuant to the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, Section 31518.

This dam inspection Report and associated inspection activities were commissioned by the City of Flint, Michigan, the dam owner. The Holloway Dam is registered with the Michigan Department of Environmental Quality (MDEQ) as Dam Number 064.

References in the report to "left" and "right" are based on the observer facing downstream.

2.0 Conclusions and Recommendations

The Holloway Dam was inspected on October 19, 2008 in accordance with Michigan P.A. 451, Part 315 criteria. The dam, including spillway and embankments was found to be in good condition. A summary of comments/recommendations is as follows:

1. The City of Flint should continue their operation and maintenance procedures as outlined in the "Holloway Reservoir Operation and Maintenance Plan".

2. The Emergency Action Plan should be exercised annually and Notification List concurrently updated.

3. Small brush should be removed from the left and right embankments.

4. Minor spalls and cracks in the spillway concrete should be monitored. These do not require immediate correction, but should be planned and budgeted in the City's long term Capital Improvement Plan (CIP).

5. The seepage monitoring weirs should be placed back into operation by repairing the eroded channel. Periodic observations of seepage rates and observed fines deposition should be performed and logged for long term data comparison.

6. Warning signs on the concrete abutments should be re-painted.

7. The security fence in the downstream right embankment should be repaired.

8. Monitor the sloughed area in the downstream right embankment and repair as needed.

9. Further inspections should be performed in accordance with P.A. 451, Part 315 regulations.

3.0 Project Information

The Holloway Dam is located on the Flint River in Richfield Township, Genesee County, Michigan (Section 11, T8N, R5E). The dam and lower one fourth of the reservoir are in Genesee County while the upper three fourths of the reservoir are in Lapeer County. The dam was built in 1954 to maintain a base flow in the Flint River for water supply and sewage dilution requirements. The Holloway Dam was previously referred to as the Richfield Storage Dam. Presently the reservoir's uses are primarily, base water flow implementation, sewage dilution and recreation. The dam consists of earth embankments and a 248 ft long gated concrete spillway structure. The total length of the dam is approximately 3,350 ft between the natural moraine banks. The top of the embankment serves as a gravel road for maintenance purposes. A steel framed walkway spans the top of the spillway structure for operation and maintenance of the gates. The embankment side slopes are 3 horizontal to 1 vertical on the upstream face and 2 horizontal to 1 vertical on the downstream face.

3.1 PERTINENT DATA

The embankment is comprised of two zones: an upstream section and key trench of compacted impervious clay; and a larger downstream section of essentially granular material, predominantly sand with some gravel.

The plans show a sheet pile cutoff wall along the full length of the dam near the upstream toe, extending 23 ft below the base of the embankment and two feet into the embankment. A subdrain system, originating just downstream of the centerline of the crest and transverse to the dam axis, is also shown. The plans indicate that this subdrain system is formed by tile drain pipes with a center-to-center drain spacing of 15 ft. Plan details indicate a graded filter surrounding the tile drain pipes. The pipes empty into a collection ditch at the toe of the downstream slope. The right embankment has been modified by installation of fill at the toe with a bench located mid point on the slope. Weep drains were extended with 6" PVC pipe.

The outlet works of the dam consist of a reinforced concrete spillway controlled by seven gates. There is a control house on each end of the spillway. A telemark water level recording gage is in the left control house.

The following is a tabulation of principal data obtained from the construction drawings.

Hazard Classification – High (per 1978 USACE report).

Length of Dam – Overall length of the dam including the concrete spillway structure and the right and left embankments is approximately 3,350 ft.

Height of Dam – The total height of the dam, defined in P.A. 451, Part 315 as the difference in elevation between the natural stream bed and the design flood elevation, is approximately 30 ft. the crest of the dam is at El. 763.0 ft.

Crest Width of Embankments – Approximately 15 ft.

Side Slopes – The earth embankments have 3.0 H to 1.0 V slopes on the upstream face and 2.0 H to 1.0 V slopes on the downstream face. The right embankment downstream slope has been modified with fill at the toe and a bench at midpoint.

Spillway: 248 ft long concrete spillway structure with:

a) two 90 ft long drum gates

b) three 20 ft long taintor gates

c) two 4 ft by 6 ft sluice gates perpendicular to the dam axis

d) 75 ft by 248 ft wide discharge apron

Cutoff: 25 ft deep steel sheet pile cutoff wall at the upstream toe of the full length of the dam, and 15 ft deep steel sheet pile cutoff wall along the downstream side of the spillway structure.

Embankments: Upstream section and key trench of compacted impervious clay and a larger downstream section of granular material, predominantly sand with some gravel.

Further details of the spillway structure and embankments are shown in **Appendix A**. These figures have been taken from the 1978 Phase I Inspection Report.

4.0 Field Inspection

An inspection of the facilities was performed by Dana M. Dougherty, PE (Stantec) on October 19, 2008. The weather on the date of inspection was clear with temperature at approximately 55°F. The impoundment elevation was near normal (summer) i.e. 755. Flow was passing over the drum gates as well as through the left (looking downstream) sluicegate.

The following items were noted: (Referenced photographs can be found in **Appendix C**.)

4.1 SPILLWAY

Overall the spillway appeared to be in excellent condition. Recent preventative maintenance work includes painting of miscellaneous metals including handrails, gates, and support beams, installation of new galvanized steel grating on the gate operator platform and patching concrete at the upper downstream end of the taintor gate piers.

Some minor items were noted with regard to concrete condition including:

1. There was spalled concrete on the top of the upstream right wingwall. The face of the wall exhibited cracking and efflorescence at this location (Ref. Photos #3 and #4).

2. There was a small crack in the right abutment immediately above the drum gate. There is no evidence of movement or displacement at this crack (Ref. Photo #6). This should be monitored.

3. Minor alligator cracking was noted in the taintor gate piers (Ref. Photos #7 and #8). These do not pose any immediate concern but should be monitored.

4. There were cracks in the left abutment and left downstream retaining walls. No displacement was noted. These cracks should be monitored for future movement (Ref. Photos #9 and #10).

5. The upper portion of the downstream end of the left downstream retaining wall has alligator cracking and effervescence. This should be monitored (Ref. Photo #12).

6. The warning signs that are painted on the upstream abutment/wingwall faces are faded and difficult to read. These should be repainted.

4.2 RIGHT EMBANKMENT

Overall the condition of the right embankment appears to be good with no significant erosion, seepage, settlement, sloughing or animal burrows noted. The following specific items were noted:

1. There was a minor amount of erosion beneath the riprap on the upstream embankment face immediately adjacent to the spillway.

2. Some brush has begun to grow on the upstream slope. This should be selectively removed (Ref Photos #14 and #16). Small natural growth such as wildflowers and grasses should remain.

3. Considerable brush was observed on the downstream embankment face and within the toe-of-slope drain. This should be removed (Ref. Photos #17 and #20).

4. For the most part weep tiles are dry. There is one section midway in the embankment where the weep tiles are active. Some sloughing of the slope was observed in this area. It appeared that this has been addressed through addition of a blanket drain with geotextile fabric. This should be monitored for further displacement.

5. A short section of the security fence was in disrepair. This should be corrected (Ref. Photo #23).

6. The seepage monitoring weir is not functioning. Flow was passing around the weir through an eroded section. This should be corrected (Ref. Photo #24).

4.3 LEFT EMBANKMENT

The observed condition of the left embankment was good to excellent. There was no evidence of significant erosion, seepage, settlement, sloughing or animal burrows. The following specific items were noted:

1. A minor amount of small brush should be removed from the downstream slope (Ref. Photo #28).

2. There was no evidence of seepage from the weep drains, however the toe-of-slope drain was flowing, in particular the final 100 ft (Ref. Photo #29).

3. The seepage monitoring weir is not functioning similar to the right side. Flow was passing around the weir through an eroded section. This should be corrected (Ref. Photo #30).

5.0 Structural Stability

The assessment of stability is based on visual observations made during our field inspection (10/19/08).

No deficiencies were noted that would impact the structural integrity of the dam; however minor items were noted that should be proactively addressed to mitigate potential future deficiencies. Over all the condition of the facility remains good.

6.0 Hydrology and Hydraulics

The MDEQ has estimated the required spillway capacity at the Holloway Dam to be 9900 cfs (reference **Appendix B**). This equates to the 200 year frequency flood which is mandated by statute – P.A. 451, Part 315, Section 324.31516.

Headwater rating curves previously produced by the USACE (1978) and Acres International (1993) indicate that this discharge capacity can be met at an impoundment elevation of approximately 755. This would allow for approximately 8 feet of freeboard. Thus, the spillway discharge capacity is sufficient to meet P.A. 451, Part 315 requirements. Furthermore, the spillway capacity at overtopping (El. 763) is approximately 40,000 cfs or ½ PMF.

The spillway capacity has also been determined with the assumption that the drum gates fail to operate and are locked in the up position (reference Ayres, Lewis, Norris & May, Inc. (ALNM) Report – 1996). The resultant 200 year impoundment elevation is computed to be approximately 761 or two feet of freeboard. Therefore, the required spillway design capacity can be met through operation of the taintor gates only.

7.0 Operation and Maintenance

The dam is operated and maintained by staff from the City of Flint Water Treatment Plant. Routine operation and maintenance is performed in accordance with the Holloway Reservoir Operation and Maintenance Plan which is on file at the City of Flint WTP.

Impoundment elevation is continuously monitored via an on-site level transducer. Instantaneous level information is available remotely to assist operations personnel in maintenance of the impoundment elevation.

During summer months, the drum gates are in a raised position and taintor gates closed. The impoundment elevation is maintained between 755.0 and 755.75 by operating the drum and/or taintor gates as needed.

The impoundment elevation is lowered in the winter to approximately elevation 751.0. The drum gates are lowered during this period.

Emergency backup power is available to operate the taintor gates in case of a power loss. An Auxiliary Generator Power System Report is available at the WTP.

The City has performed routine maintenance of the facilities on an "as needed" basis. The most recent work consisted of painting exposed steel components including the taintor gates and access platform support steel.

In addition to routine surveillance by operations staff, supervisor staff also performs an annual inspection of the facilities. Noted deficiencies are scheduled for correction the following year.

Appendix 6 - 2008 Utah Dam Safety Report

MICHIGAN PUBLIC ACT 451, PART 315
INSPECTION REPORT
UTAH DAM
GENESEE COUNTY, MICHIGAN
INVENTORY NUMBER 1275 – LOW HAZARD

FOR

CITY OF FLINT
WATER TREATMENT PLANT
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BY

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STATE OF MICHIGAN
DANA M. DOUGHERTY
ENGINEER
NO.
24737
REGISTERED PROFESSIONAL ENGINEER

INSPECTOR(S): Dana M. Dougherty – Stantec Consulting Michigan Inc.

DATE OF INSPECTION: October 19, 2008

PROFESSIONAL ENGINEER: Dana M. Dougherty, PE
STANTEC CONSULTING MICHIGAN INC.
3959 RESEARCH PARK DRIVE
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Dana M. Dougherty

Dana M. Dougherty, PE #24737

Stantec
INSPECTION REPORT
UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

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UTAH DAM
CITY OF FLINT
GENESEE COUNTY, MICHIGAN

1.0 Purpose and Authority

The purpose of the report is to present a summary of findings for the field inspection of the Utah Dam completed by Stantec Consulting Michigan Inc. (Stantec) on October 19, 2008 pursuant to the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, Section 31518.

This dam inspection Report and associated inspection activities were commissioned by the City of Flint, Michigan, the dam owner. The Utah Dam is registered with the Michigan Department of Environmental Quality (MDEQ) as Dam Number 11275.

References in the report to "left" and "right" are based on the observer facing downstream.

2.0 Conclusions and Recommendations

The Utah Dam was inspected on October 19, 2008 in accordance with Michigan P.A. 451, Part 315 criteria. The dam was found to be in fair to poor condition. A summary of comments/recommendations is as follows:

1. The stability of the exposed portion of the structure is poor and is no longer capable of serving its intended purpose.

2. The operating components of the facility (floodgates) have been decommissioned for sometime and are no longer functional.

3. The purpose of the dam (impound water for the upstream water treatment plant) is no longer needed as the Hamilton Dam, which is located downstream, provides this capability.

4. The Hamilton Dam is currently being evaluated for potential reconstruction and should the decision be made to proceed with that project the Utah Dam will serve no useful future function.

5. The spillway hydraulic capacity is deficient with regard to P.A. 451, Part 315, Section 324.31516 rules. This is further exacerbated by the fact that the partially open gates impede high flows resulting in an increased backwater.

6. The City should consider full or partial removal of the dam. It is possible that the foundation and submerged portion of the piers may be reused to support a new pedestrian crossing bridge. The minimum removal effort would consist of removing the gates from the dam. Due to the aforementioned deficiencies and related public safety liabilities the City should take immediate action perhaps concurrent with the proposed Hamilton Dam reconstruction.

3.0 Project Information

Utah Dam is located on the Flint River in the City of Flint, Genesee County, Michigan (T08N, R07E, Section 32) at the south end of Whaley Park. The site location map is shown in **Appendix A**.

Utah Dam is owned by the City of Flint and plans for the dam are on file with the City. It was designed by the Ambursen Dam Company of New York and San Francisco and built around 1928. The dam was constructed to maintain a reservoir at El. 711 to provide sufficient head on the City's water treatment plant intake pipe. The pool created by the dam was limited to the main channel of the Flint River. The dam was built between the two banks of the river and has a total length of 240 ft. It consists of a concrete gravity structure with six spillway bays and 4 ft wide piers. Each bay has a 12 ft high by 25 ft long vertical lift gate.

There are two bridge decks on the structure. The upper deck is approximately 11 ft wide and it is used to move the gate hoist along the length of the dam. The gate hoist travels the length of the dam on two No. 40 rails, each of which is supported by 15 inch "I' beams. The beams are supported by the piers.

The lower bridge deck is separated by the vertical lift gates. The downstream side of the deck is 7 ft wide and it serves as a pedestrian walkway. The upstream side of the deck is 5 ft wide and it is used by the operator to gain access to the upper deck via a steel ladder.

Presently, the dam serves as a walkway over the Flint River and as a backup for Hamilton dam for providing a head on the water intake pipe. The gates of Utah Dam are currently locked open above the normal backwater elevation created by Hamilton Dam, which is 2.2 miles downstream. Elevations given in this report are referenced to National Geodetic Vertical Datum.

Six spillway bays and vertical lift gates are contained within the structure. Pertinent data about Utah Dam is give below.

Height of Dam – The total height of the dam, defined in P.A. 451, Part 315 as the difference in elevation between the natural stream bed (El. 696.8 ft) and the design flood elevation (El. 717.2 ft) is approximately 20.4 ft.

Crest Width of Structure – 30 ft as measured along the lower deck.

Sill of Vertical Lift Gates – El. 697.3 ft.

Sketches of the dam are included in **Appendix A**.

4.0 Field Inspection

An inspection of the facilities was performed by Dana M. Dougherty, P.E. (Stantec) on October 19, 2008. The weather on the date of inspection was clear with temperature at approximately 55°F. The impoundment elevation was approximately 1.9 ft below normal elevation. The City was in the process of lowering the Hamilton Dam impoundment per directive from the MDEQ. This directive requires that the Hamilton Dam impoundment be lowered 3.25 ft.

The following items were noted (Reference photographs can be found in **Appendix C**):

1. The concrete condition on the downstream face of the dam is fair to poor. The right downstream retaining wall shows significant spalling in its top and outside corner. The left downstream retaining wall has significant spalling and cracking. The pier noses (three of five) are spalled. The access platform or walkway or the dam, concrete is in fair to poor condition. There is effervescence and cracking in the access platform support beams. There is no displacement. (Ref. Photos #1 and #5.)

2. The concrete condition of the upstream dam face is fair to poor. The noses of all piers show effervescence and some alligator cracking. This is also true for the right and left upstream retaining walls. There does not appear to be any substantial structural cracking in any of these members or displacement. There is spalling of concrete at the top of the piers as well as at the top of the abutment walls where the access platform rests. There is also some indication of spalling in the access platform beams and in some cases at the bottom of the beams themselves (Ref. Photos #2 and #6).

3. The gates are randomly open. The left gate, Bay No. 1, is 2 feet above the water level on this date. Bay No. 2 and No. 3 from the left, are 4 feet above water level on this date and Bay No. 4, 5, and 6 are 6.5 feet above water level. All dimensions reference water level to the bottom of the gate.

4. The superstructure appears to be in very poor condition. Concrete is in fair to poor condition. The operating platform, which housed a single moveable gantry crane for all six gates, has spalling in the beams as well as the piers. Protective railings are all intact, but in poor condition and require painting (Ref. Photos #7 and #8).

5. The top of the right embankment has a paved walkway with chain link fence on either side of the walkway. This is also true for the left embankment. There is also lighting at the site, utility poles in each embankment with a light fixture (Ref. Photos #3 and #4).

6. The embankments have some tree growth which should be removed.

7. On the date of the inspection, the water level is about 10.6 feet below the operating/walkway platform (El. 706.6 NGVD).

8. There is a 4 foot wide opening in the fence on the left downstream face of the dam, next to the utility pole, which allows access and is a safety issue. Also, the safety fencing that was installed on the upstream side of the dam, between the walkway and the gates, has been removed and is a safety issue.

5.0 Structural Stability

The assessment of stability is based on visual observations made during our field inspection (10/10/08).

The overall structural condition of the Utah Dam is categorized to be fair to poor. Substantial deteriorated concrete is evident with numerous spalls, cracks, and some exposed reinforcing steel. The superstructure concrete is in the poorest condition with the gate lift support structure no longer capable of supporting its intended function i.e. gate operation.

The condition of the access platforms and exposed portions of the piers is somewhat better than the superstructure but still would be categorized as poor. The submerged portion of the peirs and foundation were not inspected as part of this report, however experience with similar structures would imply that their condition would be better than the exposed components.

In conclusion, the Utah Dam structural stability will no longer support gate operation. Furthermore, continued use of the access platforms for pedestrian crossing will be dependent on future evaluation, repair and/or modification of those components.

6.0 Hydrology and Hydraulics

The MDEQ has established the required spillway capacity at the Utah Dam to be 11,800 cfs (reference **Appendix** B). This equates to the 100 year frequency flood which is mandated by statute, P.A. 451, Part 315, Section 324.31516, for dams classified as low hazard such as the Utah Dam.

The hydraulic capacity of the Utah Dam is greatly impacted by the downstream Hamilton Dam. The normal impoundment elevation of the Hamilton Dam impoundment is approximately El. 708.0 (NGVD) while the gate sill elevation of the Utah Dam is 697.3. Thus, the Utah Dam is partially submerged under normal conditions.

Overtopping of the right embankment occurs at or near El. 714.0. The 1993 Acres Report (**Appendix** B) indicates that overtopping of this embankment will be experienced at flows over 7,830 cfs. The FEMA Flood Insurance Study (**Appendix** B) shows the 100 year flood elevation at the Utah Dam to be approximately El. 716.0. Thus the right embankment is overtopped under high flow conditions due to backwater impacts from the Hamilton Dam. It should be noted that the FEMA Flood Insurance Study assumes that all six gates are operable at Hamilton Dam. Since 1991 only three gates have been operable thus the backwater impact would be greater than shown on the FEMA maps.

The Utah Dam's hydraulic capacity is further diminished by the fact that the floodgates are currently locked in a partially open position. The bottom of gate elevation for each bay (numbered left to right looking downstream) is approximately:

Bay No. 1	708.5
Bays No. 2 and 3	710.5
Bays No. 4 through 6	713.0

Under high flows (100 year El. 716.0) the gates will impede flow thereby further exacerbating flood conditions.

For the above described reasons, it is concluded that the Utah Dam does not meet spillway capacity requirements as required by statute.

7.0 Operation and Maintenance

The Utah Dam is operated and maintained by staff from the City of Flint Water Treatment Plant. The floodgates are currently non-functional and are locked in a partially open position. Power has been disconnected from the gate operators. The impoundment elevation is maintained by the downstream Hamilton Dam thereby negating the usefulness of the Utah Dam.

The City staff therefore maintains a minimal surveillance effort at the dam. Minimal preventative maintenance has been performed in the recent past. It is the City's intent to remove all or a portion of the structure as funds become available. Until that time maintenance will be limited to those items necessary to insure public safety with regard to the pedestrian bridge crossing.

Appendix 7 - 2008 Hamilton Dam Safety Report

MICHIGAN PUBLIC ACT 451, PART 315
INSPECTION REPORT
HAMILTON DAM
GENESEE COUNTY, MICHIGAN
INVENTORY NUMBER 060 – HIGH HAZARD

FOR

CITY OF FLINT
WATER TREATMENT PLANT
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BY
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INSPECTOR(S): Dana M. Dougherty – Stantec Consulting Michigan Inc.

DATE OF INSPECTION: October 19, 2008

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1.0 PURPOSE AND AUTHORITY

The purpose of this report is to present a summary of findings for the field inspection of the Hamilton Dam completed by Stantec Consulting Michigan Inc. on October 19, 2008 pursuant to the requirements of Part 315, Dam Safety, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, Section 31518.

This Dam Inspection Report and associated inspection activities were commissioned by the City of Flint, the dam owner. The Hamilton Dam is registered with the Michigan Department of Environmental Quality (MDEQ) as Dam Number 060.

References in this report to "left" and "right" are based on the observer facing downstream.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The Hamilton Dam was inspected on October 19, 2008 in accordance with the Michigan P.A. 415, Part 315 criteria. The dam was found to be in poor condition which supports the conclusion found in previous dam safety reports. Specific comments/recommendations are as follows:

1. The stability of the exposed structural components including gate piers, access and operating platforms, and abutments is poor. These components are no longer capable of serving their intended purpose.

2. Three of the floodgates have been decommissioned while the reliability of the remaining gates is suspect. With three gates operating inadequate freeboard exists at the right embankment (looking downstream). In addition upstream flood elevations will be greater than those included in the FMEA Flood Insurance maps.

3. The MDEQ mandated drawdown should be adhered to until the dam is reconstructed.

4. The City should proceed immediately to implement the preferred option from the 2008 Reconstruction Feasibility Study.

5. In the interim, the City should exercise the Emergency Action Plan (EAP) annually to insure an efficient implementation when and if needed.

3.0 PROJECT INFORMATION

Hamilton Dam is located on the Flint River in downtown Flint, Michigan near the Flint Branch of the University of Michigan campus, and approximately 800 ft. upstream from the Saginaw Street Bridge.

Plans for the current dam are on file with the City of Flint, but original design data is not available. The dam was designed by Fargo Engineering Company of Jackson, Michigan, and was constructed about 1920 by Price Brothers Company of Lansing, Michigan on the site of a previous mill dam. The dam was constructed to sustain a head for the upstream water treatment plant intake.

The existing structure is a reinforced concrete gravity dam with six gated spillway bays. Each bay has a tainter gate on the fixed crest of a concrete spillway. The six bays, each 33 ft. long, and the five piers, each four feet thick, make a total length of 218 ft. There is an end sill below the spillway and an 18 ft. concrete apron beyond the end sill. The gates are operated during flood flows.

The original 1920 dam had seven bays with tainter gates. In 1964, the southern (left) most gate, its spillway and headrace were removed.

A fish ladder was constructed through the right abutment sidewalls in 1978. Also in 1978, the right concrete abutment was modified to install an Archimedean screw pump.

Repairs to Hamilton Dam were carried out in the summer of 1992. Steel sheet piling was placed just upstream of the gates for Bays 1, 2 and 6 because of the deteriorated condition of the gates. The sheet piles were to maintain the headpond in case of gate failure. The top elevation of the sheet piles was placed near the top of the tainter gates (Elev. 707.8 ft.) in a closed position. Gate repairs were completed in Bays 3, 4, and 5. These repairs included the complete removal of the existing gates and replacement with new gates, repair of buttress and sill concrete, repair of gate trunnions, replacement of lift chains, and painting of all exposed gate steel.

The top deck of the structure is divided lengthwise into a pedestrian walkway and the gate hoist rails for the two gate hoists. The hoist rails consist of two "I" beams (18 inch and 15 inch) that are supported by the piers. The two hoists for raising the spillway tainter gates are driven by attached electric motors.

A U.S. Army Corps of Engineer's bronze disk is set flush with the bridge deck in the walkway at the second pier from the right end. Unless otherwise noted, data given in this report is based on the assumption that the E1 715.06 ft. elevation given for this benchmark is on National Geodetic Vertical Datum (NGVD).

The terrain near the dam and reservoir is urban and gently rolling. Five borings from the original plans show sand with an occasional pocket of clay or gravel in the soils overlying a soft sandstone which is 40 or 50 ft. below ground surface.

Six spillway bays and tainter gates make up the structure. Only Gates 3, 4 and 5 are currently operable. Sketches and pertinent data about Hamilton Dam are shown in **Appendix A**.

Hamilton Dam was classified by the U.S. Army Corp of Engineers as High Hazard in the 1980 Phase I Inspection Report. This classification remains in effect to date.

Plans for the original Dam construction in 1920 and plans for repairs performed in 1992 are on file with the City of Flint. Past inspection reports on file include the following:

- 1980 USACE, Phase I, National Dam Safety Program Report
- 1986 Ayres, Lewis, Norris & May, Inc. (ALNM) and Sublakes Diving Inspection Report
- 1988 MDNR Inspection Report
- 1989 Ayres, Lewis, Norris & May, Inc. (ALNM) Structural Evaluation and Reconstruction of Hamilton Dam Report
- 1993 Acres International Corp., Dam Inspection Report
- 1996 Ayres, Lewis, Norris & May, Inc. (ALNM) Inspection Report
- 1999 Paul C. Rizzo Associates, Inc. Dam Inspection Report
- 2000 USACE Hamilton Dam Condition Survey
- 2005 Soil & Materials Engineers, Inc. Dam Inspection Report
- 2008 Stantec Feasibility Study for Reconstruction

These reports have been consistent in their recommendations to undertake corrective action to address structural deficiencies within the facility. The 1989 Ayres, Lewis, Norris & May, Inc. (ALNM) and 2000 USACE Reports included estimated costs of $3,830,000 and $5,588,000 respectively to make the necessary improvements to insure dam safety and integrity. The 2008 Stantec Report estimated the reconstruction cost to be $4,901,000.

On March 14, 2008, acting under the authority of Part 315, Dam Safety of the Natural Resources and Environmental Protection Act, 1994 P.A. 451 as amended, the Michigan

Department of Environmental Quality issued an order to the City of Flint to drawdown the Hamilton impoundment 3.25 ft. to an elevation not greater than 705.25 NGVD for the purpose of public health, welfare and safety protection. The depth of necessary drawdown was computed by the MDEQ to eliminate the danger of loss of life downstream in the event of a sudden dam failure.

A permit under Part 301, Inland Lakes and Streams was issued for this activity on September 30, 2008. The City of Flint has subsequently abided by the conditions of this permit and has lowered the normal impoundment elevation to the prescribed elevation. It should also be noted that the MDEQ permit requires permanent deflation of the Obermeyer (Inflatable) Dam.

4.0 FIELD INSPECTION

An inspection of the facilities was performed on October 19, 2008 by Dana M. Dougherty, PE. The weather on the date of the inspection was clear with temperatures at approximately 55°F. The impoundment elevation was below normal by approximately 1.5 ft. The City was in the process of lowering the impoundment per directive from the MDEQ. This directive requires that the impoundment be lowered 3.25 ft. The floodgate in Bay #3 has been opened to accomplish this task.

The following items were noted during the field inspection (referenced photographs can be found in **Appendix C**):

1. The condition of the exposed concrete including piers, slabs, abutments is poor with numerous spalls, cracks and exposed reinforcing steel (Ref. Photos #1 through #4, #7, #8, #10).

2. The floodgates in Bays 1, 2 and 6 have been decommissioned by placement of steel sheeting across the face of these bays (Ref. Photos #2 and #8).

3. The City reports that the remaining floodgates (Bays 3 through 5) are operative, however, Bays 4 and 5 have not been operated with any frequency and thus their reliability is suspect.

4. The access walkway/platform remains closed to the public due to safety concerns (Ref. Photos #3 and #4).

5. Overall the condition of the dam continues to worsen with the structural integrity of numerous components compromised.

5.0 STRUCTURAL STABILITY

The assessment of stability is based on a visual observation made during our field inspection (10/19/08) and visual observations made during preparation of the 2008 Reconstruction Feasibility Study, as well as the 1989 condition survey (concrete corings).

The overall structural condition of the Hamilton Dam is poor. Exposed surfaces including gate piers, access and operating platforms and abutments all exhibit conditions that indicate these components have exceeded their useful life. Numerous spalls, cracks and exposed reinforcing steel exist.

In conclusion, the Hamilton Dam structural stability is deficient and thus this facility represents a potential liability with regard to public health, welfare and safety.

6.0 HYDROLOGY AND HYDRAULICS

The dam is regulated under State of Michigan P.A. 451 Part 315 statute. Guidelines that accompany this statute require high hazard potential dams with heights less than 40 ft. to be capable of passing a 200-year flood or the flood of record whichever is greater. For the Hamilton Dam, the 200-year flood controls and has been computed by the Michigan Department of Environmental Quality to be 13,000 cfs (reference **Appendix B**).

The computed maximum impoundment elevation for the 200-year flood event varies dependent on assumptions made with regard to the number of floodgates that are operative. In 1981, calculations were performed by the United States Geologic Survey and form the basis for the FEMA Flood Insurance mapping that is used to this day. The USGS assumed that all six floodgates were operational. The USACE also computed the maximum impoundment elevation in their 1981 National Dam Safety Inspection Report. They assumed that just two gates were operational due to the fact that the gates could not be locked in an open position and only two operators existed. In 1993 after decommissioning of Gates 1, 2 and 6, Acres International Corporation computed the maximum headwater elevation assuming that gates were operational in Bays 3, 4 and 5.

The results of these various studies is as follows (refer to **Appendix B** for more information):

Source	Estimated 200-year Impoundment Elevation NGVD Datum
1981 F.I.S. (U.S.G.S.)	709.05*
1981 Dam Safety Inspection Report (USACE)	711.6
1993 Dam Safety Inspection Report (ACRES)	712.8

** USGS added 0.95' to the computed impoundment elevation for the purpose of floodplain mapping. Therefore the floodplain mapping indicates a 200-year flood elevation of approximately 710.0 NGVD.*

It should be noted that there is uncertainty as to whether or not adequate freeboard exists at this site. The Acres report indicates that freeboard is sufficient based on the fact that the upstream right streambank area was raised in the mid 1980's. However, a recent survey conducted as part of the 2008 Reconstruction Feasibility Study indicates the elevation of this area to be similar to that shown in the 1981 USACE report i.e. ± 711.5 NGVD. Thus, it would appear that inadequate freeboard currently exists.

7.0 OPERATION AND MAINTENANCE

The Hamilton Dam is operated and maintained by staff from the City of Flint Water Treatment Plant. Floodgates in Bays 1, 2 and 6 are currently non-functional. Floodgates in the remaining bays can be operated, however their reliability is diminished due to the deteriorated condition of the operating slab.

City staff maintains the impoundment elevation by operating the gates on an as needed basis. The impoundment is currently being maintained at the MDEQ mandated level of 705.25 NGVD i.e. 3.25 ft below normal.

The City has performed minimal maintenance to the structure in anticipation of reconstruction.

Appendix 8 - Cost of Service Study – Flint Water Treatment Plant

EXHIBIT B

DRAFT

Technical Memorandum
Cost of Service Study
Flint Water Treatment Plant

I. Introduction

This Technical Memorandum describes the proposed improvements needed at the Flint Water Plant to treat Flint River water on a continuous basis. The primary foundations for this evaluation were the "Water Treatment Plant Rehabilitation – Phase II" report dated December 2003 and the "Preliminary Engineering Report, Lake Huron Water Supply, Karegnondi Water Authority" dated September 2009. The findings, as presented in the following sections, address the improvements required for the water plant to produce finished water in conformance with the current federal and state drinking water regulations. In addition, operation and maintenance costs for continuous operation have been evaluated and included in order to determine the total cost associated with using the Flint River as a source of water.

Improvements, as proposed in this evaluation, along with those previously made during the Phase I improvements program, will produce a finished water quality equal to the current water quality as received from the DWSD. The design parameters are as follows:

1) Minimum Day Demand – 10-mgd
Average Day Demand – 15-mgd (14-mgd in 2010 increasing to 15-mgd in 2050)
Maximum Day Demand – 28-mgd

2) Turbidity – 0.20 NTU

3) Hardness – 80 to 100 mg/l as $CaCO_3$

4) Cryptosporidium – 3-Log Inactivation

5) Giardia – >3-Log Inactivation

6) Viruses – >4-Log Inactivation

7) Taste and Odor – Eliminated with pre-ozonation

8) Trihalomethanes – Less than 80 μg/l

9) HAA5 – Less than 60 μg/l

As part of this investigation, an inspection of the Flint Water Plant was performed on May 3, 2011. The purpose of this inspection was to determine if the recommendations in the Phase II report, as referenced above, needed to be revised due to changed conditions or water supply needs. Based on findings from this meeting, the major adjustment to be made is the reduction of average day demand from 20-mgd to 14-mgd and maximum day demand being reduced from 36-mgd to 28-mgd. Required improvements as recommended in this study have taken these new demands into account. The conceptual design of these new facilities would allow cost effective expansion to 36-mgd, as needed, to meet future demands.

II. Required Capital Improvements

The following describes the required improvements as required for the Flint Water Plant to operate on a continual basis using the Flint River as a water source. Most of these improvements are more fully described in the Phase II report and are not repeated to avoid duplicative effort.

A. Lime Sludge Disposal

Lime sludge is proposed to be pumped from the east and west softening basins to two new 42-ft diameter thickeners (25-ft SWD) located adjacent to the plate settling building. Decant from the thickener will flow by gravity to the primary clarifier influent channel. Thickened sludge (12% solids) will be pumped to a new plate-and-frame filter press located at the north end of the WTP 1 primary settling basin. A new two-story building would be constructed at that location to house the pumping facilities and presses. Each press, located on the second floor, will have a 225-cf per hour capacity and will drop the dewatered sludge into a first floor bunker area. The dewatered cake will be transferred to a lime storage concrete bunker located approximately 60 feet north of the sludge press building. The storage bunker (100-ft x 192-ft) will have the capacity to store three to four months of dewatered lime sludge cake. About every three months, contract haulers will remove the lime sludge and place on agricultural lands that are permitted for final disposal.

The capacities of these facilities are based on average day flow of 15-mgd, maximum day demand of 28-mgd and water quality softening requirements. Based on raw water quality data provided by the City of Flint, a lime dosage of 209 mg/l, soda ash dosage of 47 mg/l and carbon dioxide dosage of 37 mg/l were used to estimate lime sludge quantities and flows.

Opinion of Probable Cost:

Site and Access:						
Site Demolition	$	129,000				
Roadway Improvements	$	385,000				
Partial Settling Basin Demolition	$	129,000				
On-site Truck Scale	$	257,000				
Subtotal Construction:			$	900,000		
Construction Contingencies (15%):			$	135,000		
Design Contingencies (5%):			$	45,000		
Engineering, Legal, Bonds & Administration (17%):			$	153,000		
Opinion of Probable Cost:					**$**	**1,233,000**
Thickener Basins - 42 ft Diameter:						
Two Thickener Mechanisms	$	310,000				
Two Concrete Basins (25 ft SWD)	$	513,000				
Two Geodesic Dome Covers	$	180,000				
Install Equipment	$	257,000				
Site Work	$	97,000				
Utilities, Piping and Process	$	193,000				
Subtotal Construction:			$	1,550,000		
Construction Contingencies (15%):			$	232,500		
Design Contingencies (5%):			$	77,500		
Engineering, Legal, Bonds & Administration (17%):			$	263,500		
Opinion of Probable Cost:					**$**	**2,124,000**

Filter Presses and Building:

Two-225 cf Plate & Frame Press	$ 1,650,000			
Building (70 ft x 60 ft)	$ 3,331,000			
MEP	$ 1,089,000			
Site Utilities	$ 129,000			
Subtotal Construction:		$ 6,199,000		
Construction Contingencies (15%):		$ 929,850		
Design Contingencies (5%):		$ 309,950		
Engineering, Legal, Bonds & Administration (17%):		$ 1,053,830		
Opinion of Probable Cost:			**$**	**8,493,000**

Lime Storage Bunker and Site Work:

12 ft Concrete Walls and Slab	$ 833,000			
Frame and Fabric Building Cover	$ 325,000			
Site Improvements	$ 385,000			
Front End Loader (5 cyd)	$ 308,000			
Site Utilities	$ 513,000			
Subtotal Construction:		$ 2,364,000		
Construction Contingencies (15%):		$ 354,600		
Design Contingencies (5%):		$ 118,200		
Engineering, Legal, Bonds & Administration (17%):		$ 401,880		
Opinion of Probable Cost:			**$**	**3,239,000**
Total for Lime Disposal :			**$**	**15,089,000**

B. Soda Ash Feed System

In order to remove the non-carbonate hardness, soda ash will be needed to meet the finished water hardness concentrations. Two new 800 #/hour feeders will be needed to meet the dosage requirements. Each of these feeders will be connected to the existing silos.

Opinion of Probable Cost:

Demolition of Existing Feeders	$ 20,000			
Two 800 #/hr Feeders	$ 112,000			
MEP	$ 109,000			
Chemical	$ 77,000			
New Pneumatic Fill System	$ 58,000			
Subtotal Construction:		$ 376,000		
Construction Contingencies (15%):		$ 56,400		
Design Contingencies (5%):		$ 18,800		
Engineering, Legal, Bonds & Administration (17%):		$ 63,920		
Opinion of Probable Cost:			**$**	**516,000**

C. Additional Chemical Storage

During the Phase I improvements, the MDEQ did not mandate 30-day chemical bulk storage requirements since the plant was a redundant water supply to the DWSD. However, if the facility becomes a continuously operated treatment plant, then additional chemical storage must be added to meet the minimum storage volume requirements. To comply with the regulations, new oxygen, nitrogen and carbon dioxide storage facilities must be provided as follows.

Liquid Carbon Dioxide:
- Capacity – 34 tons
- Vaporizer – 750 #/hour @ 300 psig
- Piping – Schedule 80 Carbon Steel and Schedule 40 - 304L Stainless Steel

Liquid Oxygen
- Capacity – 9000 gallons
- Operating pressure – 75 psi
- Feed Rate – 175 scfm
- Piping – Type K Copper

Liquid Nitrogen
- Capacity – 540 gallons
- Operating pressure – 100 psi
- Feed Rate – 1 scfm
- Piping – Type K Copper

Opinion of Probable Cost:

Carbon Dioxide Storage Facilities	$	328,000		
MEP	$	103,000		
Oxygen & Nitrogen Storage Facilities	$	961,000		
MEP	$	109,000		
Subtotal Construction:			$	1,501,000
Construction Contingencies (15%):			$	225,150
Design Contingencies (5%):			$	75,050
Engineering, Legal, Bonds & Administration (17%):			$	255,170

Opinion of Probable Cost: $ 2,057,000

D. Electrical and SCADA Improvements

Section 9, relating to power and controls, of the Phase II study was prepared by Dmytryka Jacobs Engineers (DJE). The scope of the Phase II work did not include detailed investigations of the water plant site-wide power distribution nor the secondary power distribution within each of the facility structures. However, a number of observations and basic recommendations were presented in Section 9 by DJE.

The Flint Water Plant currently uses 2400V as primary power throughout the facility. All of the power feeders in the plant site are 5kV rated and it appears the existing switchgear is also rated at 5kV. Most of the major electrical improvements installed during Phase I were dual voltage (2400/4160) equipment in anticipation of the plant power being changed to 4160V in the near future. This change would allow the existing network of power feeders to handle approximately twice the power and would eliminate running new feeders to various portions of the plant.

The current sub-station has two 2.5MVA transformers running in parallel for a total capacity 5 MVA. These old transformers are not equipped with cooling fans. The full connected load to these transformers is estimated to be 6.97 MVA while the estimated power load at 36 MGD is 4.22MVA. Based on these estimates there is sufficient power for the plant with both sub-station transformers in service. Even though the transformers are owned by Consumers Energy, it could take weeks to replace one of these main transformers in the event of a unit failure, which will result in reduced treatment and pumping capacity. The sub-station switchgear was installed in 1960 and is antiquated and difficult to maintain.

The two existing Fairbanks Morse generators are currently inoperable and would cost approximately $1M to rehabilitate. The DJE team recommended installing two new emergency generators in lieu of re-building the existing units.

Section 9 of the Phase II report provides sufficient detail for the purposes of this report, but a detailed electric system evaluation of the entire plant should be performed prior to any major improvements to this facility.

While LAN did not perform a detailed review of the WTP electrical system during our site visit, it appears that all of the DJE findings are still pertinent. We, therefore, concur with the improvements as recommended by DJE in the Phase I report.

Opinion of Probable Cost:

Substation Upgrade	$	961,000		
Standby Power Generation	$	2,242,000		
Pump Station No. 4 Upgrade	$	1,365,000		
Filter Press Building Feeder	$	87,000		
WTP SCADA, Equipment & Programming	$	720,000		
Telemetry System Equipment & Programming	$	103,000		
Computers, Software & Training	$	155,000		
Filter Transfer PS Power Feeders	$	135,000		
Emergency PS Power Feeders	$	145,000		
Subtotal Construction:			$	5,913,000
Construction Contingencies (15%):			$	886,950
Design Contingencies (5%):			$	295,650
Engineering, Legal, Bonds & Administration (17%):			$	1,005,210
Opinion of Probable Cost:			**$**	**8,101,000**

E. Post-Chlorination and Zebra Mussel Control

The previous report recommended changing the disinfection system from gaseous chlorine to sodium hypochlorite due to the potential for hazardous gas release and the requirements imposed by new federal regulations. Previous treatability studies have not addressed the potential impact of re-growth in the system due to ozonation by-products. These impacts should be addressed prior to proceeding with final plans for using river water.

The Flint River is known to be infested with Zebra mussels and mitigation measures will have to be implemented if the plant is placed into continuous operation. A sodium permanganate feed system is proposed to address these concerns.

Opinion of Probable Cost:

Demolition of Existing Equipment	$	39,000				
Storage Tanks	$	9,000				
Metering Pumps and Tables	$	11,000				
Piping, Valves & Tables	$	9,000				
Containment	$	59,000				
Installation	$	108,000				
Subtotal Construction:			$	235,000		
Construction Contingencies (15%):			$	35,250		
Design Contingencies (5%):			$	11,750		
Engineering, Legal, Bonds & Administration (17%):			$	39,950		
Opinion of Probable Cost:					**$**	**322,000**

F. Security Issues

For water plant security issues, please refer to City of Flint Vulnerability Assessment. Details are omitted in this report due to confidentiality.

Not available at the time of the previous report, a source water monitoring system is included in the study due to recent advancements in technology. The proposed system design is based on Hach Model SC1000, equipped with UVAS, NH4D, pH, ORP, turbidity and DO probes.

Opinion of Probable Cost:

Security Improvements	$	145,000				
Source Water Monitoring System	$	95,000				
Subtotal Construction:			$	240,000		
Construction Contingencies (15%):			$	36,000		
Design Contingencies (5%):			$	12,000		
Engineering, Legal, Bonds & Administration (17%):			$	40,800		
Opinion of Probable Cost:					**$**	**329,000**

G. PS No. 4 - Low and High Service Pumps

Section 7 of the Phase II report included recommendations to replace two of the low lift pumps and two of the high lift pumps along with various other improvements. During the site visit, it was apparent the condition of this facility has continued to deteriorate. Furthermore, with the reduction in water system demands, the various pump capacities are no longer properly sized to efficiently meet the new plant flow ranges. The pumps and motors are oversized and are operating outside their best efficiency ranges and should be replaced due to age, condition and cost to operate.

Additionally, some of these pumps cannot be operated due to excessive vibrations in the shaft and steady bearings. Existing vibration monitors are functioning as designed and are shutting the power off to the motors to avoid damage.

For low lift service, it is proposed to install two 10-mgd and two 15-mgd (nominal ratings) vertically mounted pumps equipped with low voltage inverter duty motors. The motors would be powered by low

voltage variable frequency drives. This will provide a firm rated capacity of approximately 35-mgd in low lift capacity.

For high lift service, it is proposed to install one 10-mgd, two 15-mgd and one 20-mgd (nominal ratings) pumps equipped with medium voltage inverter duty motors. These motors will be power by medium voltage variable frequency drives. This combination of pumps will provide a firm rated capacity of 40-mgd.

Opinion of Probable Cost:

Demolition of Existing Equipment	$	135,000		
Install Two (2) 10 MGD @ 40 ft of TDH Vertically Mounted Pumps with 125 HP, 480 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	$	473,000		
Install Two (2) 15 MGD @ 40 ft of TDH Vertically Mounted Pumps with 150 HP, 480 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	$	495,000		
Install One (1) 10 MGD @ 190 ft of TDH Vertically Mounted Pump with 450 HP, 4160 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	$	245,000		
Install Two (2) 15 MGD @ 190 ft of TDH Vertically Mounted Pumps with 700 HP, 4160 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	$	520,000		
Install One (1) 20 MGD @ 190 ft of TDH Vertically Mounted Pump with 800 HP, 4160 V Inverter Duty Motor with 20 ft of Shaft & Steady Bearings	$	285,000		
Piping, Valves, Supports & Bearings	$	480,000		
Intermediate Platforms, Ladders & Stairs	$	360,000		
Ventilation & Boiler Systems	$	340,000		
Install Three (3) Low Voltage VFD Units	$	85,000		
Install Four (4) Medium Voltage VFD Units	$	2,250,000		
Subtotal Construction:			$	5,668,000
Construction Contingencies (15%):			$	850,200
Design Contingencies (5%):			$	283,400
Engineering, Legal, Bonds & Administration (17%):			$	963,560

Opinion of Probable Cost: $ 7,766,000

H. Filter Transfer Station to Dort Reservoir and UV Inactivation

Under the requirements as outlined in the USEPA drinking water regulations addressing potential microbial contaminants, additional treatment technologies and enhancement of existing processes must be implemented to comply with these regulations.

As required under the enhanced surface water treatment rules, it is essential for water utilities to address giardia, cryptosporidium, viruses and bacteria in finished water. The level of treatment is dependent on

the source water classification. The City of Flint will need to perform a two-year source water study to determine the bin placement for the Flint River. For the purposes of this report, a Bin 4 placement was selected due to the nature of the watershed and, therefore, it is assumed enhanced Ct and UV inactivation will be required.

Reservoir No. 3 does not provide sufficient Ct to meet the current regulations, therefore, Dort Reservoir will need to be placed into the process train. Since Dort Reservoir does not match the hydraulic profile of the plant, an intermediate pump station will be required. This new facility will also include a UV inactivation system to comply with the enhanced water quality regulations.

This proposed facility, located west of the filters and south of Dort Reservoir, will house three 14-mgd (nominal rating) variable speed pumps with inverter duty, low voltage motors for a firm rated capacity of 28-mgd. Housed in a separate part of this same structure will be the UV system that will be equipped with three 12" medium pressure units with a rated capacity of 28-mgd.

Opinion of Probable Cost:

Site Work & Utilities	$	77,000		
Building (80 ft x 60 ft)	$	1,440,000		
Three (3) 14 MGD @ 40 ft of TDH, Vertically Mounted Pumps with 150 HP, 480 V Inverter Duty Motor	$	535,000		
MEP	$	940,000		
Valves and Controls	$	205,000		
Install Three (3) 12" MP UV Units	$	590,000		
UV Piping & Controls	$	368,000		
Ventilation & Boiler Systems	$	165,000		
Install Three (3) Low Voltage VFD Units	$	85,000		
Piping Connections	$	125,000		
200 ft of 30" Water Main	$	200,000		
600 ft of 36" Water Main	$	420,000		
Subtotal Construction:			$	5,150,000
Construction Contingencies (15%):			$	772,500
Design Contingencies (5%):			$	257,500
Engineering, Legal, Bonds & Administration (17%):			$	875,500

Opinion of Probable Cost: $ 7,056,000

I. Emergency Interconnect Pumping Station

The City of Flint and Genesee County DWWS have entered into an agreement to provide 8-mgd of back-up service to each other under emergency conditions. There are several alternatives for pumping station locations and configurations to accomplish this interconnect. For the purposes of this report, a station located west of the filter building was selected as the most practical from and operational cost perspective. While the opinions of cost presented below indicate that these pumps will be housed in their own structure, it is feasible to house the pumps in the filter transfer station for potential savings.

Preliminary design for this pumping station include two constant speed 8-mgd pumps equipped with soft starts and medium voltage motors. A reverse flow control station will be included within the same structure to allow for flow from the DWWS to assist the City of Flint. Approximately three miles of 24-inch pipeline will be needed to connect the two systems.
Opinion of Probable Cost:

Site Work & Utilities	$	90,000		
Building (32 ft x 24 ft)	$	245,000		
Install Two (2) 8 MGD @ 290 ft of TDH, Vertically Mounted Pumps with 600 HP, 4160V Motor	$	380,000		
MEP	$	335,000		
Valves and Controls	$	128,000		
Reverse Flow Control Station	$	110,000		
Ventilation Systems	$	35,000		
16000 ft of 24" Water Main	$	4,992,000		
Subtotal Construction:			$	6,315,000
Construction Contingencies (15%):			$	947,250
Design Contingencies (5%):			$	315,750
Engineering, Legal, Bonds & Administration (17%):			$	1,073,550
Opinion of Probable Cost:			**$**	**8,652,000**

The opinions of capital cost presented in the preceding sections are tied to an ENR Index of 8688 to match the September 2009 Lake Huron Water Supply Report. Furthermore, the contingency percentages included with each opinion of cost are the same as in the September 2009 report. The total opinion of probable project cost of these proposed improvements is as follows:

Lime Sludge Disposal	$	15,089,000
Soda Ash Feed System	$	516,000
Additional Chemical Storage	$	2,057,000
Electrical and SCADA Improvements	$	8,101,000
Post-Chlorination and Zebra Mussel Control	$	322,000
Security Issues	$	329,000
PS No. 4 - Low & High Service Pumps	$	7,766,000
Filter Transfer Pumping Station & UV	$	7,056,000
Emergency Interconnect Pumping Station	$	8,652,000
Total Opinion of Probable Project Cost:	**$**	**49,888,000**

III. Cost of Additional Operation

The City of Flint currently operates the water treatment plant periodically during the year to maintain the systems and to meet regulatory requirements. The water treatment plant is staffed with various classifications of employees to operate and maintain the facility for these minimal operations.

As part of this work, and to develop all costs of providing water service from the Flint River, it is necessary to determine the probable cost for operating and maintaining this facility for continuous operation. Water quality differences between the Flint River and Lake Huron are significant and require different treatment chemicals and dosages. Most noticeable is the fact that Lake Huron water does not require softening which negates the need for softening process and the associated lime sludge disposal.

The primary cost parameters that are included in this difference are labor, chemicals, residual disposal and electrical power. Each will be discussed in the following sections. These costs were projected through the year 2050.

A. Labor

Additional staffing was discussed and developed with representatives from the City of Flint to provide full time coverage on a 24/7/365 schedule, plus provide staff for residual management and operations of the various dams. Hourly rates and fringe benefits were based on current budget figures and inflated at a rate of 3% for future costs. The following table outlines the proposed staffing a cost for this operational element.

Classification	Number	Cost/Hr	Hrs/Year	Total	Fringe (%)	Total
Operators	12	$ 20.00	2080	$ 499,200	90.40%	$ 950,477
Maintenance	4	$ 25.00	2080	$ 208,000	90.40%	$ 396,032
Laboratory QA/QC	2	$ 24.00	2080	$ 99,840	90.40%	$ 190,095
Laboratory SDWA	2	$ 20.00	2080	$ 83,200	90.40%	$ 158,413
Planned Overtime	NA	MIXED	8320	$ 178,048	90.40%	$ 339,003

This estimate represents approximately $2,034,000 per year of additional labor.

B. Chemicals

Chemical costs are based on the projected average day water demand of 14-mgd and the average dose for each of the chemicals based on the raw water quality information and other operational records. Further, data from the previous treatability work performed during the Phase I improvements was also incorporated into these estimates. Chemical suppliers and other water utilities were contacted to obtain current chemical purchase costs which were adjusted by the ENR ratio back to an index of 8688. Where necessary, transportation costs to the Flint, MI area were included. The following summarizes the chemical costs associated with treating the Flint River water.

Chemical	Dose(mg/l)	Cost/#	Cost/ MGD
Ferric	44.50	$0.24	$89.07
Lime	209.00	$0.10	$174.31
Soda Ash	47.00	$0.29	$113.67
CO_2	37.00	$0.10	$30.86
Cl_2	3.00	$0.34	$8.51
Fluoride	1.00	$0.33	$2.75
Phosphate*	1.00	$0.51	$4.25
		Cost per MGD	$423.42

*Costs range from $0.51 to $0.96 per pound

In addition to the above, the cost of ozone will need to be added which is approximately $20.08 per million gallons per day per mg/l dose. This cost includes oxygen, nitrogen and power costs.

C. Residual Disposal

This category is divided into two groups: clarifier sludge collected in the plate settling basins and lime sludge from the softening process. The clarifier sludge is pumped from the clarifier basins by zone (six zones per train, three trains, total of 18 zones) to the plant main drain. As part of the Phase I work, the main drain was connected to a new wastewater pumping station located south of the filter gallery building. This pump station discharges the collected residuals to the city's sanitary sewer system. Nearly all of the filter wash water is recirculated back to the head of the ozone facility for re-use.

The cost to treat clarified sludge discharged into the sanitary sewer system is calculated as follows:

Plate Clarifier Sludge	
Flow (MGD)	14
SS (mg/l)	75
Primary Sludge (#/d	13,435
% Solids	2%
Sludge (gals/day)	80,500
Sludge (cf/day)	10,762

Based on the City of Flint's current wastewater charges of $1.00 per 100 cf, the annual cost would be $39,200 per year.

Lime/Soda Ash softening generates large quantities of residual wastes that have high disposal costs. The treatment proposed in this study involves pumping the sludge, at about 4% concentration, from the softening basins to two gravity thickeners, where it will concentrate to about 12% solids. After thickening, sludge will be pumped to the filter presses to be dewatered to approximately 55% solids. The filter presses will drop the cake into a lower bunker where it will be removed by an end loader to the main storage bunker. About every three months, the sludge will be loaded onto trucks and applied to agricultural land.

The volume of sludge is estimated as follows:

Sludge Production from Clarifier

Reaction	meq/l	meq/l as $CaCO_3$	meq/l as $Mg(OH)_2$
CO_2	0.25	0.25	0
$Ca(HCO_3)_2$	4.65	9.30	0
$Mg(HCO_3)_2$	0.30	0.60	0.30
$MgSO_4$	0.89	0.89	0.89
Excess Lime	1.25	1.25	0
	Total meq/l	12.28	1.19
	Less Practical Limits meg/l	0.60	0.20
	Precipitate Produced meq/l	11.68	0.99
	Precipitate Produced mg/l	584	49
	Precipitate Produced #/MG	4872	412
	Total #/MG	5284	

WTP Flow (MGD)	14	27		
Dry Sludge Production in #/day	73,983	142,681		
@ 4% Solids (gals/day)	221,771	427,701		
@ 12% Solids (gals/day)	73,924	142,567		
@ 12% Solids (gals/week)	517,466	997,970		
Dry Sludge Production (tons/week)	259		SG $CaCO_3$	2.71
Number of Hours per Week to Press	48		SG $Mg(OH)_2$	2.36
Dry Sludge Processed (#/hr)	10,789		SG solids	2.68
@ 55% Solids Sludge Processed (#/hr)	19,617			
55% Solids Sludge (#/cy)	2571		Sludge Solids =	55% as $CaCO_3$
@ 55% Solids Sludge Processed (cf/hr)	206		Sludge Unit Wt. =	95.22 pcf

Based on the preceding, 471 tons of softening sludge at 55% solids will be handled each week based on average flow and chemical dosage. Several Michigan water facilities were contacted to obtain lime sludge hauling and disposal costs. From this data a rate of $18.50 per wet ton was selected as a reasonable rate for disposal cost. This rate will result in an annual cost of $453,000.

D. Power

Practically all of the additional power costs are associated with low lift, intermediate transfer and high service pumping. Additional power costs will be used for process and handling of the softening sludge. The City of Flint is currently paying $0.07 per kwhr for service at the water plant. Power costs are calculated as follows:

TDH (ft) - High	190
TDH (ft) - Filter Transfer	40
TDH (ft) - Low	40
TDH Total (ft)	270
Pump Eff. (W to W)	80.00%
$/kwhr	$0.070
Pumping Cost Per MGD	$99.51
Solids Handling per MGD	$4.98
Total Power Cost per MGD	$104.49

Annual costs associated with the operation and maintenance of the Flint Water Plant are summarized in the attached tables following this section.

IV. Project Implementation Schedule

There are a number of issues that will impact the implementation schedule for this work. The source water studies to define bin number associated with cryptosporidium and giardia will take approximately two years. Part of these studies can be performed concurrently with design, but sufficient work will need to be performed to avoid impacting design schedule or work. A planning period of one year should be allowed for preliminary water quality and regulatory evaluations prior to initiating design work. Design of this project will require 10 to 12 months, with an additional three months required for permitting. After permits are received, allow three months for bidding and contract execution. Major equipment procurement and construction will take from 24 to 30 months. Plant commissioning will take about 2 months.

Total time required from notice to proceed to project completion 52 months to 60 months. This time frame does not include financing issues.

EXHIBIT C

Lockwood, Andrews & Newnam

June 10, 2013

Mr. Brent Wright
City of Flint
Water Treatment Plant Supervisor
4500 N. Dort Highway
Flint, MI 48505

RE: Flint Water Treatment Plant Rehabilitation – Phase II

Dear Mr. Wright,

Lockwood, Andrews & Newnam, Inc. (LAN) is pleased to submit our Scope of Services and Fee Proposal for the above referenced project. LAN's staff has the knowledge, expertise and the technical professionals to handle all aspects of the project. Our staff has firsthand knowledge of the Flint Water Treatment Plant (FWTP) and the type of improvements that has taken place in there since 1997. Our team of professionals was heavily involved with the original Project Plan which secured $36 Million dollars of DWRF Low Interest Loan funding and related improvements to the plant that took place during the late 1990 and early 2000.

In addition, LAN is also working with **Rowe Professional Services**, another local engineering firm, who is familiar with the Water Treatment Plant, its staff and the City of Flint to help provide engineering and survey services related to the upcoming Phase II Improvements. The attached chart highlights the history of LAN's and Rowe's staff involvement with the FWTP for your review and reference.

Our design team, including Rowe and other sub-consultants, are very familiar with the current set up and operation of the plant and we are ready and eager to help the City of Flint swiftly and cost effectively implement the design improvements required for Phase II. These improvements is intended to help the City operates the plant on a full time basis using the Flint River and ultimately be available for treating Lake Huron Water when connected to the Karegnondi Water Authority (KWA) System in the near future.

We are excited about this opportunity and our ability to expedite the design elements to address the City's desire to operate the Plant on a full time basis as quickly as practically possible. We recommend that our tasks 1 & 2 happen concurrently as to minimize the time delay to finalize the intended design parameters.

Schedule is critically important if the City desires to use FWTP to treat water from the Flint River as an interim water supply source. Therefore, testing and preliminary engineering work will need to get started immediately if the City's goals are to be met. The experience and familiarity that LAN and Rowe have with the city's WTP and facilities will allow us to start quickly without having to familiarize new staff with the City's facilities.

1311 SOUTH LINDEN ROAD • Suite B • Flint, Michigan 48532 • 810.820.2682 • Fax 810.820.2703 • www.lan-inc.com

We look forward to working with you and your staff to address the City's needs. Our tentative schedule could be amended to adjust the timelines to best suit the City and address the requirements of the MDEQ and other interested stakeholders.

Respectfully Submitted,
Lockwood, Andrews & Newnam, Inc.

J. Warren Green, PE
Project Director

Samir F. Matta, PE
Senior Project Manager

LAN & ROWE Staff Involvement Matrix

Project List	Staff Names					
	Warren Green	Samir Matta	Jeff Hansen	Steve Luoma	Eric Brown	Jim Redding
Flint Water Treatment Plant Project Plan 1997-1998	X	X	X			
Flint Water Treatment Plant Phase 1	X	X	X	X	X	
Flint Water Treatment Plant Phase 2	X	X	X	X	X	
Flint Water Treatment Plant Full Operation Report 2003	X					
Flint Water Treatment Plant - Flint River Report 2011	X		X			X

Our Staff has been involved with the changes in the Flint Water Treatment Plant since 1997 and are well acquainted with its operation and functionality.

CITY OF FLINT, MICHIGAN

Phase II Rehabilitation and Improvements of the Flint Water Plant

The purpose of this agreement is to enter into a contract pertaining to rehabilitation of and improvements to the Flint Water Plant to provide water supply continuous service utilizing the Flint River as a water source and to set forth the rights and responsibilities of the parties, the City of Flint (hereinafter "City") and Lockwood, Andrews and Newnam, Inc. (hereinafter "Engineer").

Applicable Law: This contract shall be governed by and interpreted according to the laws of the State of Michigan pertaining to contracts made and to be performed in this state.

Arbitration: Engineer agrees that for all claims, counterclaims, disputes, and other matters arising out of or relating to this agreement, Engineer must request the City's consent to arbitrate within 30 days from the date the Engineer knows or should have known the facts giving rise to the claim, dispute or question.

(a) Notice of a request for arbitration must be submitted to the City in writing by certified mail or personal service upon the City Attorney...

(b) Within 60 days from the date a request for arbitration is received by the City, the City shall inform Engineer whether it agrees to arbitrate. If the City does not consent, Engineer may proceed with an action in the appropriate court. If the City does consent, then within 30 days of the consent each party shall submit to the other the name of one person to serve as an arbitrator. The two arbitrators together shall then select a third person, the three together shall then serve as a panel in all proceedings. Any decision concurred in by a majority of the three shall be a final binding decision. The City's failure to respond to a timely, conforming request for arbitration is deemed consent to arbitration.

(c) The costs of the arbitration shall be split and borne equally between the parties and such costs are not subject to shifting by the arbitrator.

(d) The remedy for Engineer's failure to comply with this provision is dismissal of the action.

City Income Tax Withholding: Engineer and any subconsultant engaged in this contract shall withhold from each payment to his employees the City income tax on all of their compensation subject to tax, after giving effect to exemptions, as follows:

(a) Residents of the City:
At a rate equal to 1% of all compensation paid to the employee who is a resident of the City of Flint.

(b) Non-residents:
At a rate equal to 1/2% of the compensation paid to the employee for work done or services performed in the City of Flint.

These taxes shall be held in trust and paid over to the City of Flint in accordance with City ordinances and State law. Any failure to do so shall constitute a substantial and material breach of this contract.

Compensation: The City shall pay for such scope of services as have been set forth herein, a contract price not to exceed $2,534,640 upon submission of proper invoices, releases, affidavits, and the like. Engineer recognizes that the City does not guarantee it will require any set amount of services. Engineer's services will be utilized as needed and as determined solely by the City of Flint. Engineer expressly recognizes that it has no right to payment of any amount exceeding $2,534,640 for the scope of services as set forth herein. Engineer agrees that oral agreements by City officials to pay a greater amount are not binding.

1. Engineer shall submit itemized invoices for all services provided under this Agreement identifying:

   (a) The date of service
   (b) The name of person providing the service and a general description of the service provided.
   (c) The unit rate and the total amount due.

Invoices shall be submitted to:

City of Flint Water Plant
Brent Wright
4500 N. Dort Highway
Flint, MI 48505

City of Flint
Accounts Payable
P.O. Box 246
Flint, MI 48501-0246

It is solely within the discretion of the City as to whether Engineer has provided a proper invoice. The City may require additional information or waive requirements as it sees fit. The City will notify the Engineer of any errors or lack of sufficient documentation within 14 days of receipt of the invoice.

Disclaimer of Contractual Relationship With Subconsultants: Nothing contained in the Contract Documents shall create any contractual relationship between the City and any Subconsultant.

Certification, Licensing, Debarment, Suspension and Other Responsibilities: Engineer warrants and certifies that Engineer and/or any of its principals are properly certified and licensed to perform the duties required by this contract in accord with laws, rules, and regulations, and is not presently debarred, suspended, proposed for debarment or declared ineligible for the award of any Federal contracts by any Federal agency. Engineer may not continue to or be compensated for any work performed during any time period where the debarment, suspension or ineligibility described above exists or may arise in the course of Engineer contractual relationship with the City. Failure to comply with this section

constitutes a material breach of this Contract. Should it be determined that Engineer performed work under this contract while in non-compliance with this provision, Engineer agrees to reimburse the City for any costs that the City must repay to any and all entities.

Force Majeure: Neither party shall be responsible for damages or delays caused by Force Majeure or other events beyond the control of the other party and which could not reasonably have been anticipated or prevented. For purposes of this Agreement, Force Majeure includes, but is not limited to, adverse weather conditions, floods, epidemics, war, riot, strikes, lockouts, and other industrial disturbances; unknown site conditions, accidents, sabotage, fire, and acts of God. Should Force Majeure occur, the parties shall mutually agree on the terms and conditions upon which the services may continue.

Good Standing: Engineer must remain current and not be in default of any obligations due the City of Flint, including the payment of taxes, fines, penalties, licenses, or other monies due the City of Flint. Violations of this clause shall constitute a substantial and material breach of this contract. Such breach shall constitute good cause for the termination of this contract should the City of Flint decide to terminate on such basis.

Indemnification: To the fullest extent permitted by law, Engineer agrees to defend, pay on behalf of, indemnify, and hold harmless the City of Flint, its elected and appointed officials, employees and volunteers and other working on behalf of the City of Flint, including the Project Manager, against any and all claims, demands, suits, or losses, including all costs connected therewith, and for any damages which may be asserted, claimed, or recovered against or from the City of Flint, its elected and appointed officials, employees, volunteers or others working on behalf of the City of Flint, by reason of personal injury, including bodily injury or death and/or property damage, including loss of use thereof, which may arise as a result of Engineer's acts, omissions, faults, and negligence or that of any of his employees, agents, and representatives in connection with the performance of this contract. Should the Engineer fail to indemnify the City in the above-mentioned circumstances, the City may exercise its option to deduct the cost that it incurs from the contract price forthwith.

Independent Engineer: No provision of this contract shall be construed as creating an employer-employee relationship. It is hereby expressly understood and agreed that Engineer is an "independent Engineer" as that phrase has been defined and interpreted by the courts of the State of Michigan and, as such, Engineer is not entitled to any benefits not otherwise specified herein.

Insurance/Worker's Compensation: Engineer shall not commence work under this contract until he has procured and provided evidence of the insurance required under this section. All coverage shall be obtained from insurance companies licensed and authorized to do business in the State of Michigan unless otherwise approved by the City's Risk Manager. Policies shall be reviewed by the City's Risk Manager for completeness and limits of coverage. All coverage shall be with insurance carriers acceptable to the City of Flint. Engineer shall maintain the following insurance coverage for the duration of the contract.

(a) Commercial General Liability coverage of not less than one million dollars ($1,000,000) combined single limit with the City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers, named as "Additional Insureds." This coverage shall be written on an ISO occurrence basis form and shall include: Bodily Injury, Personal Injury, Property Damage, Contractual Liability, Products and Completed Operations, Independent Engineers; Broad Form Commercial General Liability Endorsement, (XCU) Exclusions deleted and a per contract aggregate coverage. This coverage shall be primary to the Additional Insureds, and not contributing with any other insurance or similar protection available to the Additional Insureds, whether said other available coverage be primary, contributing, or excess.

(b) Workers Compensation Insurance in accordance with Michigan statutory requirements, including Employers Liability coverage.

(c) Commercial Automobile Insurance in the amount of not less than $1,000,000 combined single limit per accident with the City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers, named as "Additional Insureds." This coverage shall be written on ISO business auto forms covering Automobile Liability, code "any auto."

(d) Professional Liability - Errors and Omissions. All projects involving the use of Architects, civil engineers, landscape design specialists, and other professional services must provide the City of Flint with evidence of Professional Liability coverage in an amount not less than one million dollars ($1,000,000). Evidence of this coverage must be provided for a minimum of three years after project completion. Any deductibles or self-insured retention must be declared to and approved by the City. In addition, the total dollar value of all claims paid out on the policy shall be declared. At the option of the City, either the insurer shall reduce or eliminate such deductibles or self-insured retention with respect to the City, its officials, employees, agents and volunteers; or Engineer shall procure a bond guaranteeing payment of losses and related investigation, claim, administration, and defense expenses.

Engineer shall furnish the City with two certificates of insurance for all coverage requested with original endorsements for those policies requiring the Additional Insureds. All certificates of insurance must provide the City of Flint with not less than 30 days advance written notice in the event of cancellation, non-payment of premium, non-renewal, or any material change in policy coverage. In addition, the wording "Endeavor to" and "but failure to mail such notice shall impose no obligation or liability of any kind upon the company, its agents or representatives" must be removed from the standard ACORD cancellation statement. These certificates must identify the City of Flint, Risk Management Division, as the "Certificate Holder." Engineer must provide, upon request, certified copies of all insurance policies. If any of the above polices are due to expire during the term of this contract, Engineer shall deliver renewal certificates and copies of the new policies to the City of Flint at least ten days prior to the expiration date. Engineer shall

ensure that all sub-consultants utilized obtain and maintain all insurance coverage required by this provision.

Laws and Ordinances: Engineer shall obey and abide by all of the laws, rules and regulations of the Federal Government, State of Michigan, Genesee County and the City of Flint, applicable to the performance of this agreement, including, but not limited to, labor laws, and laws regulating or applying to public improvements.

Modifications: Any modifications to this contract must be in writing and signed by the parties or the authorized employee, officer, board or council representative of the parties authorized to make such contractual modifications under State law and local ordinances.

No Third-Party Beneficiary: No Engineer, sub-consultant, or other person dealing with the principal Engineer shall be, nor shall any of them be deemed to be, third-party beneficiaries of this contract, but each such person shall be deemed to have agreed (a) that they shall look to the principal Engineer as their sole source of recovery if not paid, and (b) except as otherwise agreed to by the principal Engineer and any such person in writing, they may not enter any claim or bring any such action against the City under any circumstances. Except as provided by law, or as otherwise agreed to in writing between the City and such person, each such person shall be deemed to have waived in writing all rights to seek redress from the City under any circumstances whatsoever.

Non-Assignability: Engineer shall not assign or transfer any interest in this contract without the prior written consent of the City provided, however, that claims for money due or to become due to Engineer from the City under this contract may be assigned to a bank, trust company, or other financial institution without such approval. Notice of any such assignment or transfer shall be furnished promptly to the City.

Non-Disclosure/Confidentiality: Engineer agrees that the documents identified herein as the contract documents are confidential information intended for the sole use of the City and that Engineer will not disclose any such information, or in any other way make such documents public, without the express written approval of the City or the order of the court of appropriate jurisdiction or as required by the laws of the State of Michigan.

Non-Discrimination: Engineer shall not discriminate against any employee or applicant for employment with respect to hiring or tenure; terms, conditions, or privileges of employment; or any matter directly or indirectly related to employment, because of race, color, creed, religion, ancestry, national origin, age, sex, height, weight, disability or other physical impairment, marital status, or status with respect to public assistance.

Notices: Notices to the City of Flint shall be deemed sufficient if in writing and mailed, postage prepaid, addressed to **Inez Brown, City Clerk, City of Flint, 1101 S. Saginaw Street, Flint, Michigan 48502**, or to such other address as may be designated in writing by the City from time to time. Notices to Engineer shall be deemed sufficient if in writing and mailed, postage prepaid, addressed to **J. Warren Green, PE, Lockwood, Andrews and Newnam, Inc., One Oakbrook Terrace, suite 207, Oakbrook Terrace, Illinois, 60181**, or to such other address as may be designated in writing by Engineer from time to time.

Records Property of City: All documents, information, reports and the like prepared or generated by Engineer as a result of this contract shall become the sole property of the City of Flint.

Scope of Services: This project involves the evaluation and upgrade of the Flint Water Plant (FWP) to provide continuous water supply service to the City of Flint (Flint) and its customers. The FWP was extensively renovated in the early 2000's to provide a redundant supply to the Detroit Water and Sewer Department's (DWSD) single 72-inch treated water transmission main. Improvements installed during the renovation included: traveling screens, ozone disinfection, rapid mix units, flocculation basins, plate settlers, softening units, PSF re-carbonation systems, complete filter system rehabilitation, clarification residuals disposal, lime sludge pumping system, chemical storage and feed systems, laboratory facilities, operations room and SCADA system. Maximum day design capacity was 36-mgd. The improvements described above were designated as Phase I.

Phase I improvements were constructed in five separate contracts, referred to as Segments 1 – 5. Since the completion of Phase I improvements, the plant has been periodically operated, usually for about a two-week period and without softening with the water being discharged back to the river. The last plant run, without softening, was done in April 2013, however, the last run, with full chemical treatment to include softening, dates back to 2007.

Recently, Flint joined the Karegnondi Water Authority (KWA) and plans to supply Lake Huron water to its customers. The use of Lake Huron as a water source will significantly modify the above outlined improvements since softening will not be required. However, due to contractual relations with the DWSD, Flint is investigating the possibility of placing the FWP into operation using the Flint River as a primary source for approximately two years and then converting to lake water when available. During this two year interim period, Flint would consider supplying water to Genesee County provided the FWP proves capable of treating and supplying the required 40 MGD maximum day demand. This new operational scenario along with the reduction in maximum day capacity to 18-mgd, after KWA System completion, creates the need for a modified plan that balances the short and long term needs for Flint.

This planned work has three primary tasks that must be performed to develop a cost effective plan for the Flint immediate and long term needs. In order to meet the short schedules, some portions of these tasks will be performed concurrently, while some may be performed consecutively. Based on opinions of probable costs from past reports, the estimated construction cost to prepare the water plant for continuous operation using Flint River water for the interim period is on the order of $33 to $34 million. Construction costs for each component from past reports are shown under Task 3. Note that costs would need to be updated to today's dollars.

Task 1 is a plant test run scheduled for this summer to test the treatment systems and hydraulic capacity of the plant. Task 2 would be the development of an engineering planning report to define the immediate and long term improvements using the Flint River

as a source of water. Task 3 would be fast track design of the immediate improvements for continuous operation and treatment of Flint River water.

Task 1: Plant Test Run

1) Meet with FWP staff and other stakeholders as necessary to review current condition of the water plant facilities and equipment. Develop a preliminary list of issues or concerns that will impact the planned test run.

2) Obtain copies and review existing Phase I documents as provided by Flint. Recreate design calculations, such as plant hydraulic headlosses, as needed to develop plant test run parameters.

3) Perform plant site visit with FWP staff to ascertain the condition of the facilities and equipment.

4) Develop plant test run protocol for submission to MDEQ.

5) Meet with MDEQ representatives to review and discuss test run protocol. Incorporate MDEQ comments into final plant test run protocol.

6) Provide assistance and training/support to the FWP staff on implementing the test run protocol.

7) Collect data and information generated during plant test run. Evaluate the plant and unit systems performance for water quality and hydraulic capacity.

8) Meet with Flint staff, MDEQ and other stakeholders as necessary to discuss plant run findings and present conclusions and recommendations. Prepare and submit interim technical memorandum to City of Flint outlining conclusions and recommendations from the plant test run.

9) Schedule, coordinate and meet with equipment and material vendors as required.

Task 2: Engineering Planning Report

1) Using the technical memorandum as referenced in the preceding section, develop conceptual plan for both immediate and long term improvements.

2) Review site plan information and utilities to define needs and constraints related to immediate and long term proposed improvements.

3) Attend frequent meetings with Flint utility staff to discuss and review potential and recommended improvements to meet the needs for immediate and long term water supply needs

4) Define the finished water quality parameters and goals.

5) Develop plans for temporary facilities as needed, such as lime sludge disposal, to minimize cost for the interim period.

6) Define the basis of design for the needed improvements along with an opinion of probable construction cost referenced to a specific ENR Index value.

7) Re-evaluate issues defined in the 2011 Analysis of the Flint River report for permanent withdrawal versus interim withdrawal from the river such as Holloway Reservoir water levels and Flint River minimum flow requirements.

8) Submit a draft of the planning report to Flint for review.

9) Attend up to four meetings with Flint staff and the MDEQ to finalize the planning report.

10) Incorporate review comments into planning report and deliver final to Flint.

Task 3: Design Phase Services

1) Final design parameters as required will be determined during the course of the investigative phase of this work, however the following target goals should be considered as a minimum:

   a) Minimum Day Demand – 10-mgd
   Average Day Demand – 12-mgd
   Maximum Day Demand – 18-mgd

   b) Turbidity – 0.10 NTU

   c) Hardness – 80 to 100 mg/l as $CaCO_3$

   d) Cryptosporidium – 3-Log Inactivation

   e) Giardia – >3-Log Inactivation

   f) Viruses – >4-Log Inactivation

   g) Taste and Odor – Eliminated with pre-ozonation

   h) Trihalomethanes – Less than 80 µg/l

   i) HAA5 – Less than 60 µg/l

2) Professional engineering services will include final design, plans, contract documents, and bidding assistance for the following improvements.

   a) Additional oxygen and nitrogen chemical storage along with associated piping and appurtenances for the ozone system. [$2,057,000]

   b) Post chlorination and zebra mussel control. [$322,000]

   c) Electrical and SCADA improvements as outlined in the Phase II project plan. [$8,101,000]

   d) Evaluate long term clarification residuals disposal method. [TBD]

   e) Replace existing low service pumps with new 15-mgd and 20-mgd pumps and 480V motors. Replace existing high service pumps with new 10-mgd and 20-mgd pumps equipped with medium voltage inverter duty motors and variable frequency drives. High service pump numbers 7 and 8 motors will be replaced with medium voltage inverter duty motors and variable frequency drives. Suction piping on existing 6-mgd pump will be altered as needed. [$7,766,000]

   f) Address plant security issues. [$329,000]

   g) Provide auxiliary power to maintain plant operations at limited capacity during power failures. [Included in (2) (c) above]

   h) Improvement of Ct values for regulatory compliance. [TBD]

   i) Filter transfer pumping station and Dort Reservoir. [$5,743,000]

   j) Emergency interconnect with GCDC-WWS. [$8,657,000]

   k) Temporary lime sludge processing and handling equipment. [TBD]

3) Construction phase services scope and fee will be determined after design phase is completed.

Schedule: LAN understands that timeliness is critical for this project and will provide whatever resources are necessary to expedite the project. The following general timeline is anticipated:

Task 1 – Plant Run:	July 8 – Aug. 16
Task 2 – Report / Basis of Design Development	June 17 – Oct. 14
Task 3 – Design Phase	Oct. 14 – TBD

The extent of design will be determined following the plant test run and water plant condition assessment.

Severability: In the event that any provision contained herein shall be determined by a court or administrative tribunal to be contrary to a provision of state or federal law or to be unenforceable for any reason, then, to the extent necessary and possible to render the remainder of this Agreement enforceable, such provision may be modified or severed by such court or administrative tribunal so as to, as nearly as possible, carry out the intention of the parties hereto, considering the purpose of the entire Agreement in relation to such provision. The invalidation of one or more terms of this contract shall not affect the validity of the remaining terms.

Standards of Performance: Engineer agrees to exercise independent judgment and to perform its duties under this contract in accordance with sound professional practices. The City is relying upon the professional reputation, experience, certification, and ability of Engineer. Engineer agrees that all of the obligations required by him under this Contract shall be performed by him or by others employed by him and working under his direction and control. The continued effectiveness of this contract during its term or any renewal term shall be contingent upon Engineer maintaining his certification in accordance with the requirements of State law.

Subcontracting: No subcontract work, if permitted by the City, shall be started prior to the written approval of the sub-consultant by the City. The City reserves the right to accept or reject any sub-consultant.

Termination: This contract may be terminated by either party hereto by submitting a notice of termination to the other party. Such notice shall be in writing and shall be effective 30 days from the date it is submitted unless otherwise agreed to by the parties hereto. Engineer, upon receiving such notice and prorated payment upon termination of this contract shall give to the City all pertinent records, data, and information created up to the date of termination to which the City, under the terms of this contract, is entitled.

In the event of a failure by either party to perform any material provision of this Contract, the other side shall give written notice of the breach along with 30 days to cure the breach. If after the 30 day period the breach has not been cured, the non-breaching party may terminate the contract. Either party may also terminate the contract if required by law to do so.

Time of Performance: Engineer's services shall commence immediately upon receipt of the notice to proceed and shall be carried out forthwith and without reasonable delay.

Union Compliance: Engineer agrees to comply with all regulations and requirements of any national or local union(s) that may have jurisdiction over any of the materials, facilities, services, or personnel to be furnished by the City. However, this provision does not apply if its application would violate Public Act 98 of 2011.

Waiver: Failure of the City to insist upon strict compliance with any of the terms, covenants, or conditions of this Agreement shall not be deemed a waiver of any term, covenant, or condition. Any waiver or relinquishment of any right or power hereunder at any one or more times shall not be deemed a waiver or relinquishment of that right or power at any other time.

Whole Agreement: This written agreement and the documents cited herein embody the entire agreement between the parties. Any additions, deletions or modifications hereto must be in writing and signed by both parties.

IN WITNESS WHEREOF, the parties have executed this contract this June _____, of 2013.

ENGINEER:
Lockwood, Andrews and Newnam, Inc.

J Warren Green

J. Warren Green, PE
Director of Engineering

WITNESS:

Samir F. Matta

Samir F. Matta, PE
Senior Project Manager

CITY OF FLINT, a Michigan Municipal Corp.:

____
Edward J. Kurtz
Emergency Financial Manager

____
Michael K. Brown
City Administrator

APPROVED AS TO FORM:

____
Peter M. Bade
City Attorney

Appendix A

DETAIL LEVEL OF EFFORT BY TASK

LOCKWOOD, ANDREWS AND NEWNAM, INC.

PHASE II - CITY OF FLINT WTP REHABILITATION

Date : June 10, 2013

TASK I - WATER TREATMENT PLANT TEST RUN SUPPORT				
CLASSIFICATION	HOURS	BILLING RATE	LABOR COST	TOTAL
Project Director	96	$ 240.00	$ 23,040.00	
Senior Project Manager	40	$ 220.00	$ 8,800.00	
Project Manager	120	$ 180.00	$ 21,600.00	
Project Engineer (PE)	80	$ 150.00	$ 12,000.00	
Design Engineer (EIT)	120	$ 120.00	$ 14,400.00	
Project Controls Manager	16	$ 105.00	$ 1,680.00	
Total Staff Hours	**336**			
Total Labor + Direct Overhead			**$ 81,520.00**	
Sub-Consultant(s)				
Expenses				**$2,500.00**
Total Task I				**$84,020.00**

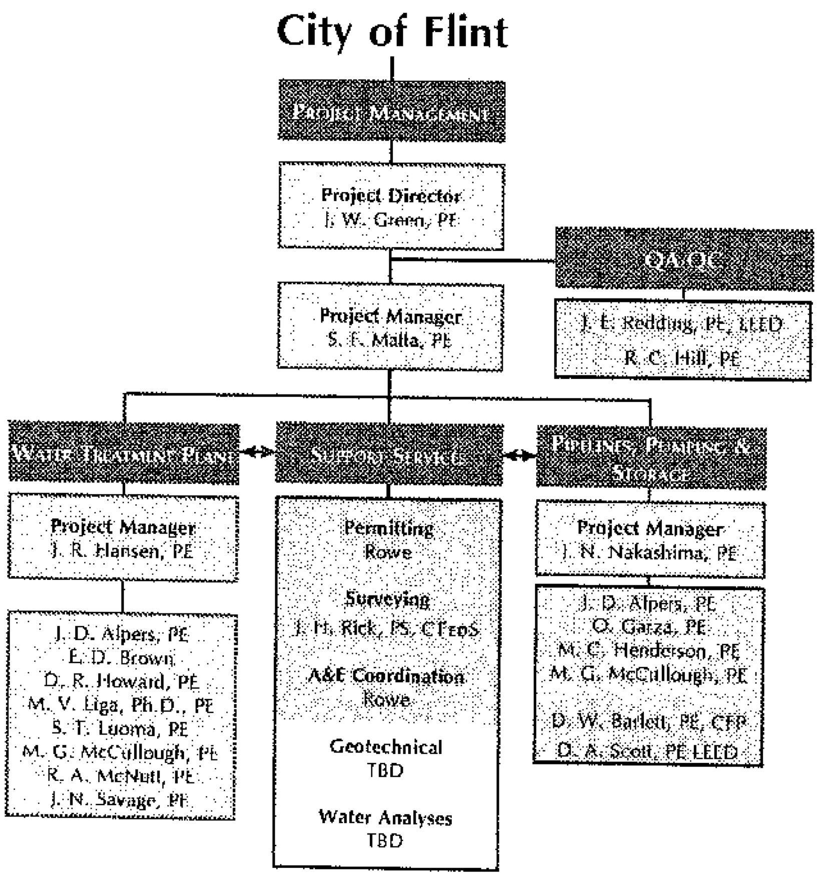
TASK II - ENGINEERING PLANNING REPORT				
CLASSIFICATION	HOURS	BILLING RATE	LABOR COST	TOTAL
Project Director	24	$ 240.00	$ 5,760.00	
Senior Project Manager	40	$ 220.00	$ 8,800.00	
Project Manager	120	$ 180.00	$ 21,600.00	
Sr. Electrical Engineer	60	$ 185.00	$ 11,100.00	
Project Engineer (PE)	120	$ 150.00	$ 18,000.00	
Design Engineer (EIT)	120	$ 118.00	$ 14,160.00	
CADD Designer	40	$ 112.00	$ 4,480.00	
Project Controls Manager	8	$ 105.00	$ 840.00	
Total Staff Hours	**468**			
Total Labor Including Overhead			**$ 84,980.00**	
Sub-Consultant(s)				
Expenses				**$2,000.00**
Total Task II				**$86,980.00**

TASK III - FINAL DESIGN AND BIDDING SERVICES				
CLASSIFICATION	**HOURS**	**BILLING RATE**	**LABOR COST**	**TOTAL**
Project Director	240	$ 240.00	$ 57,600.00	
Senior Project Manager	440	$ 220.00	$ 96,800.00	
Project Manager	920	$ 180.00	$ 165,600.00	
QA/QC VE	400	$ 215.00	$ 86,000.00	
Sr. Structural Engineer	160	$ 190.00	$ 30,400.00	
Structural Engineer	600	$ 160.00	$ 96,000.00	
Sr. Electrical Engineer	320	$ 185.00	$ 59,200.00	
Electrical Engineer	600	$ 155.00	$ 93,000.00	
Sr. Mechanical	160	$ 160.00	$ 25,600.00	
Mechanical Engineer	320	$ 127.00	$ 40,640.00	
Project Engineer (PE)	2200	$ 150.00	$ 330,000.00	
Design Engineer (EIT)	3200	$ 120.00	$ 384,000.00	
CADD Designer	4800	$ 112.00	$ 537,600.00	
Project Controls Manager	240	$ 105.00	$ 25,200.00	
Total Staff Hours	**14600**			
Total Labor + Direct Overhead			**$ 2,027,640.00**	
Sub-Consultant(s)				
Surveying			Allowance	**$ 50,000.00**
Geotechnical			Allowance	**$ 35,000.00**
Architectural			Allowance	**$ 200,000.00**
Water Quality Analysis			Allowance	**$ 25,000.00**
Expenses				**$ 26,000.00**
Total Task III				**$ 2,363,640.00**

Appendix B

Org Chart & Staff Resumes

Project Team



Prime: Lockwood, Andrews & Newnam, Inc.

Subconsultants: ROWE Professional Services Company | TBD

Project Team

J. Warren Green, PE
Director of Engineering

Education:
Bachelor of Science, Civil Engineering
Mississippi State University, 1978

Registration:
Professional Engineer, Michigan, No. [illegible]

Years of Experience:
34

Background
Warren Green brings more than 34 years of experience in engineering management and supervision of complex water treatment and transmission facility projects. He has guided water system improvements through all necessary phases including feasibility studies, pilot testing, design, financial evaluation, land acquisition, construction, start-up, and operation. During his career he has worked on approximately 20 water treatment projects. Mr. Green serves as the Director of Water Treatment & Supply at Lockwood, Andrews & Newnam, Inc. and in this role; he has total firm responsibility for all water treatment projects.

Mr. Green has worked with several municipal utility clients throughout the U.S. and prior to his more than 24 years as a consulting engineer; he managed the water division, which included a 52-mgd surface water treatment plant, for the Public Works Department, City of Jackson, Mississippi.

Additionally, Mr. Green is a previous Class A certified water operator for approximately 20 years and currently teaches basic, intermediate and advanced water system operator training classes. He has taught courses including Class A, B, C, and D 15-week certification classes and numerous one- and two-day seminars from basic math to advanced water treatment technologies. For the Illinois Section of AWWA, Mr. Green currently teaches seminars for water system operator certification training and continuing education units.

Related Experience - Water Treatment Plants
Water Treatment Plant Expansion, City of Flint, Michigan—Mr. Green served as project manager for the preparation of a preliminary design report to upgrade the existing water treatment plant to provide a redundant water supply from the Detroit Water and Sewer Department. Based on recommendations in this report, the water treatment plant improvement project was funded and initiated. The original plant (constructed in the 1950's) had a capacity of 24-mgd and had not been in service since 1968. The City of Flint, in order to meet the regulatory requirements for a redundant supply, elected to renovate this existing facility and to increase the plant capacity to 36-mgd. The project included the evaluation of advanced treatment technologies to meet the current and proposed drinking water regulations. Selected processes included a 1300-ppd LOX ozone facility and contact basin, new rapid mix and tapered flocculation basins, plate settling basins, dual media filtration with air/water backwash, solids contact lime/soda softening units, PSF recarbonation system, residuals processing equipment, site improvements. Chemical systems renovation included ferric chloride, powdered activated carbon, polymers, calcium oxide, chlorine and hydrofluosalic acid. Also included were new employee facilities, water quality laboratory, and SCADA system.

Water Treatment Plant Study, City of Flint, Michigan—Mr. Green was the project manager for the preparation of a preliminary design report for additional improvements to the Flint water treatment plant for operation on a continuous basis as opposed to the current standby status. Recommended improvements included the addition of lime sludge treatment and handling facilities, replacement of the low and high lift pumps and motors, standby power generators, UV disinfection, electrical and SCADA improvements, and additional chemical storage.

Water Treatment Pilot Plant, City of Flint, Michigan—Design, construction, and operation of a custom-built ozone pilot plant for detailed evaluation of ozone treatment for the Flint River. The Flint River water contained high levels of TOC that needed to be removed to comply with the Surface Water Treatment Rule (SWTR). The results of the study indicated that ozonation in conjunction with enhanced coagulation provided the required removal levels of TOC to meet the requirements of the SWTR. The results from this study were used in the design criteria development for the constructed plant improvements.

Water Treatment Plant Study, Division of Water and Waste Services, Genesee County Drain Commissioners Office, Genesee County, Michigan—Project Manager for the preliminary design of a 120-mgd surface water treatment

Project Team

J. WARREN GREEN, PE, CONTINUED

plant. Proposed treatment processes included ozonation, clarification, plate settling, dual media filtration, UV disinfection, and residuals treatment systems. Assignment included developing basis of design, plan and elevation of drawings of water treatment plant, plant piping layout, site drawings and opinions of cost.

Water Treatment Plant Study, Saginaw-Midland Municipal Water Supply Corporation, Bay City, Michigan—Preliminary Evaluation and Design of WTP and Associated Water System Facilities, Saginaw-Midland Municipal Water Supply Corporation, Bay City, Michigan: As Director of Engineering, Mr. Green oversaw the site evaluation and preliminary design for a 22-mgd surface water treatment plant (WTP) and associated water system facilities in the Bay Area to serve four potential municipal customers. The evaluation included verification of the design flow rate, development emergency water supply options, preliminary treatment plant design based on membrane technology, WTP building layout and sizing, finished water storage, high service pumping, and routing of transmission mains. Preliminary design of the WTP included low service pumping and screening; membrane unit sizing, layout, and piping connections; chemical feed systems; clean-in-place (CIP) equipment, tanks, and chemical waste neutralization; backwash waste treatment and disposal; Ct analysis; and disinfection options including chlorine feed and ultraviolet light. Coordination with applicable regulatory agencies, detailed cost analysis, and a wholesale raw water customer option were also provided.

Water Treatment Plant Renovation (1997), Green Bay Water Utility, Green Bay, Wisconsin—In 1996, Mr. Green was in responsible charge for evaluating the potential impact of the current and proposed drinking regulations on the Green Bay Water Utility's treatment system as well as addressing potential cryptosporidium control issues after the outbreak in Milwaukee, WI. The purpose of this study was to recommend any additional facilities that were needed to ensure a safe and adequate water supply into the next century. The comprehensive report presented a wide range of options, including microfiltration, ultrafiltration, and ozonation. The respective advantages and disadvantages, life cycle cost comparisons, operational impacts, and specific recommendations were also included.

Based on the recommendations included in this report, improvements were initiated at the Green Bay Water treatment plant. These improvements included a 42-mgd LOX ozone facility with three 600 –pound per day generators, 42-mgd rapid mix chamber, 28-mgd flocculation basin, chemical feed systems, filter wash water recirculation basin with a variable speed pump station, and a sludge lagoon with decant towers and return pumping system. This work increased the rated plant capacity to a firm 28-mgd.

Water Treatment Plant Expansion (2004), Green Bay Water Utility, Green Bay, Wisconsin—In 2001, the Green Bay Water Utility entered into negotiations with surrounding suburbs to supply water for a potential regional system. Mr. Green led the technical study team to develop conceptual facility designs and financial options for the Green Bay Water Utility to supply this proposed regional system.

Treatment options evaluated for this potential 100-mgd system included expansion of the conventional treatment system along with the use of advanced technologies such as ultrafiltration and UV disinfection. Also included with this report was the analysis of the raw and treated water transmission systems including required storage, pumping, and metering facilities. As part of this study, a separate cost of service evaluation was performed based on the RCNLD method.

Based on the results of the negotiations, the utility embarked on the expansion of the filter plant to meet the needs of the new additional customers. Mr. Green was in responsible charge for the design and construction management services for this expansion of the Green Bay Water Treatment plant to initially increase the rated plant capacity from 28- to 42-mgd, with provisions to increase the facility to a rated capacity of 55-mgd. The work involved the construction of 14-mgd capacity of slow mix basins, a 14-mgd plate clarification structure, rehabilitation of 12 dual media filters, a sodium hypochlorite structure and associated chemical storage and feed systems, and a 0.5-mg elevated wash water tank.

One of the most challenging aspects of this project included rehabilitation of 12 existing center gullet filters with new filter media, underdrains, and surface wash system. To enhance the filter performance, pilot testing was performed on different media gradations and thicknesses. This pilot testing was performed over a one-year period to address seasonal variations in water quality and temperature. The final media selection included 12 inches of filter sand and 20 inches of anthracite. The existing Wheeler filter bottoms were retrofitted with porous plate inserts to eliminate the support gravel which also allowed for increased media thickness. Each filter was equipped with new laser nephelometers to monitor filter performance. These improvements increased rated capacity to 55-mgd at 4.0 gpm/sf with one unit out of service, increased filter run times by approximately 45% and resulted in an average finished water turbidity of 0.02 NTU.

Project Team

J. WARREN GREEN, PE, CONTINUED

Water Treatment Plant Renovation, City of Jackson, Mississippi—Project manager for the renovation, including design and construction, of a 52-mgd conventional surface water treatment plant. Project included replacement of chemical feed systems for aluminum sulfate, hydrated lime (pre and post),powdered activated carbon, coagulant aid polymer, chlorine, ammonia and hydrofluosalic acid. The work also involved the rebuilding of 10 – 1-mgd, 6 – 2-mgd and 12 – 2.5-mgd rapid sand filters. Rebuilding efforts involved the repair and/or replacement of vitrified clay underdrains and media removal and replacement. New filter control valves and actuators were also provided in the piping galleries.

Water Treatment Pilot Plant, City of Joliet, Illinois—Mr. Green was the project manager for the design of a 100-gpm pilot treatment plant that included clarification and membrane filtration processes. The purpose of this work was to develop the necessary design parameters for a 34-mgd surface water treatment plant. This design included the parallel evaluation of two membrane units, manufactured by different companies, to determine the most cost-effective design of the treatment process.

Treatment Plant Forensic Evaluation, Department of Public Utilities, Joliet, Illinois—Retained as expert to evaluate the structural failure of five pressure filter underdrains on multi-cell, dual media, horizontal pressure filters for radium removal using the HMO process. Work involved detailed media, hydraulic loading and system control analyses.

Pump Stations

Pumping Station Improvements and Expansion (to 45-mgd), Green Bay Water Utility, Green Bay, Wisconsin—Mr. Green is responsible for the design and contract administration for this project. In 1956, the Green Bay Water Utility changed its water supply source from groundwater to Lake Michigan. As part of the system a 24-mgd pumping station was constructed on the shore of Lake Michigan on the north side of Kewanee, Wisconsin.

The original pumping station was equipped with five vertically mounted split case centrifugal DeLaval pumps taking suction from a wetwell and discharging into a common header. Over the past decade, replacement parts for the existing pumps have become more increasing difficult to obtain from after-market suppliers. Due to this reason and the equipment age, designs were developed for the systematic replacement of the pumps, suction piping and discharge header. During the course of the design, it was also requested to increase the station capacity from 42- to 45-mgd be evaluated to meet projected system demands.

As the selection of pumping equipment proceeded, it became apparent that the original wetwell design would not provide sufficient NPSH for the new pumps. After extended research, two pump models were found that could operate under the NPSH limitations, but the driver horsepower would increase from 800 HP to 1250 HP. These increases would require replacement of the incoming electrical feed, the MCC and the emergency generators. After meeting with the client, the design team recommended the investigation of using vertical turbine pumps for the rehabilitation project.

By changing the design concept to VFD equipped vertical turbines, the NPSH issues have been resolved and the selected pump models can use 800-HP drivers so the electrical issues have also been addressed.

DuPage Pump Station, DuPage Water Commission, DuPage County, Illinois—Project Manager for contract administration and construction management for a 185-mgd, firm rated capacity pump station. This facility is equipped with three 30-mgd vertically mounted split case centrifugal pumps (1750-HP), four 30-mgd horizontally mounted split case centrifugal pumps (1750-HP) and two 15-mgd horizontally mounted split case centrifugal pumps (800-HP). These pumps take suction from a common 84-inch header which is connected to a dual cell 30 MG concrete reservoir and discharge to two 72-inch headers. The station and piping systems are designed for a total capacity of 270-mgd.

Lexington Pump Station, DuPage Water Commission, DuPage County, Illinois—Project Manager for contract administration and construction management for a 340-mgd, firm rated capacity pump station. This facility is equipped with four 40-mgd vertically mounted split case centrifugal pumps (2000-HP), four 40-mgd horizontally mounted split case centrifugal pumps (2000-HP) and two 120-mgd horizontally mounted split case centrifugal low service pumps (2000-HP). These pumps take suction from dual 96-inch headers which are connected to a dual cell 30 MG concrete reservoir and discharge into two 84-inch headers. The station and piping systems are designed for a total capacity of 400-mgd.

Primary Effluent Pumping System (PEPS), Expansion III, Clark County Water Reclamation District (CCWRD), Las Vegas, Nevada—LAN partnered with Whiting-Turner Construction for this Design-Build project in Las Vegas, Nevada. Mr. Green is performing QA/QC on this project,

Project Team

J. Warren Green, PE, Continued

whose primary purpose is the expansion of the existing Primary Effluent Pumping Station from its current peak flow capacity of 120-mgd, to a peak capacity of 320-mgd. In addition to the expansion of the existing wet well and pumping capacity, the project involves the design and construction of a number of associated facilities including 4,000 LF of underground pipelines ranging from 30 inches to 96 inches in diameter, miscellaneous above ground process piping, structural modifications to overhead canopy, electrical system design, odor control system design, and large diameter sanitary sewer pipe rehabilitation.

Water Pumping Station Rehabilitation, Village of Oak Brook, Department of Utilities, Oak Brook, Illinois—As Project Manager, Mr. Green was responsible for the design and contract administration of a 5.0-mgd water pumping station rehabilitation. The project included replacing the four vertically-mounted split case centrifugal pumps with new pumps and electric drivers. For improved operation capability, the electric motors were equipped with variable frequency drives so station output could be optimized to system demand.

Surface Water Intake, Division of Water and Waste Services, Genesee County Drain Commissioners Office, Genesee County, Michigan—Mr. Green served as the Project Director for design engineering services of a new water supply intake system for the Genesee County Drain Commissioner – Division of Water and Waste Services in Genesee County, Michigan. Located on the western shore of Lake Huron at the county line between Sanilac and St. Clair counties, the new 85-mgd water supply intake system consists of two (2) intake structures (timber cribs), an intake pipeline (78- and 60-inch), an onshore junction chamber and including a zebra mussel control system.

Each intake crib is of an octagonal shape (48' L x 48' W x 14' H) with a rated capacity of 65-mgd. Two cribs were provided for system redundancy. The main intake pipeline is 78-inch diameter, has a capacity of 85-mgd, and extends to the furthest intake, Crib #2. At approximately 3,200 feet from shore, a wye fitting on the 78-inch pipeline branches off and reduces to a 60-inch intake pipeline to Crib #1. Two (2) submerged steel stop log chambers are provided on the upstream run and branch of the wye fitting for isolation of each intake crib. Frazil ice mitigation is addressed in the design by providing large intake port openings and is further addressed with the selection of wood as the primary material used in the construction of the cribs as its low thermal conductivity minimizes the formation of anchor ice on its surface. The cribs were designed with 12"x 12" and 6"x12" Douglas fir, No. 1 Structural, RC, Heavy timbers that are joined with steel tie rods and drift pins. The cribs are designed to resist hydrodynamic forces and to be floated partially submerged from shore to their final location.

The onshore junction chamber was designed as a 38-foot inside diameter, 91-foot deep secant pile outer wall with a 5-foot thick bottom pressure slab, an 18-inch thick interior liner wall for a finished interior diameter of 35-feet, and a 12-inch thick top slab. Complicating the design and construction of the junction chamber is the existing artesian groundwater condition at the site, which imposes significant hydrostatic and uplift loads on the structure. The 78-inch intake pipeline terminates inside the junction chamber with a 78"x 78" fabricated stainless steel slide gate with stem extension to the top slab and a pedestal-mounted manual actuator capable of attachment to a portable electric actuator. As this is the first phase of the overall water supply initiative, the junction chamber walls were designed with a blockout for tunneling and piping connection to the future lake pumping station.

Pump Station Renovation and Improvements, Saginaw-Midland Municipal Water Supply Corporation, Bay City, Michigan—Mr. Green had responsible charge for the design and contract administration for the construction of Junction Pumping Station discharge piping system modifications. Piping modifications included the installation of 36-, 48-, and 60-inch diameter steel yard piping for increasing station capacity from 115- to 165-mgd. The project also included the construction of two cast-in-place concrete vaults to house 36-inch control valves and 36-inch mag-meter. A new maintenance building, with an area of 2,400 square feet, was also included as part of the work.

Industrial Pump Station, Gulf Coast Water Authority, Texas City, Texas—Project Director the preparation of a Preliminary Engineering Report (PER) to develop alternatives for the repair or replacement of the existing Industrial Pump Station (IPS). The IPS was initially constructed in 1949 with three (3) pumps. Through the years, numerous modifications and additions were completed. Currently, the station has nine (9) vertical turbine pumps, each with a nominal capacity of 7,500 gpm at 80 psi each. The IPS provides raw water to four major industrial customers, including Dow Chemical, Valero, Marathon Petroleum, and Eastman Chemical. Interruption to the water supply cannot be tolerated for any significant length of time.

The PER defined four alternatives for consideration by the Gulf Coast Water Authority. The recommended alternative included reusing the existing intake structure and pump

suction wetwell, as well as making piping connections to the existing 36- and 42-inch transmission mains. As physical inspections of the existing intake/wetwell structure and underground transmission mains were outside the scope of the original PER work, LAN was requested to further investigate the existing conditions and evaluate the risks associated with reusing the intake/wetwell structure and connections to the existing transmission mains. The objective of this supplemental report is to identify and evaluate potential risks associated with reusing the existing intake structure, pump suction wetwell and making piping connections to existing 36-inch steel and 42-inch cast iron pipe transmission mains, as defined in Alternative 2 of the PER, against the potential risks of building a new pumping facility as defined in Alternative 1 of the PER.

Usually, risk analysis studies are based on a cost-to-benefit/risk evaluation. However, due to the proprietary nature related to the cost of water service interruption, this evaluation was presented on the basis of potential risk and down time associated with cause of service interruption. Based on, the assumption that service interruption of any significant time period is not acceptable and the anticipated risk levels, it is recommended the GCWA implement PER Alternative 1 and proceed with the design and construction of a new pumping station facility.

Transmission Mains

54-Inch Transmission Main, Green Bay Water Utility, Wisconsin—Principal-in-Charge for the design, contract administration and construction of approximately 17 miles of 54-inch diameter steel water transmission main. This project involved the installation of the pipeline through numerous wetlands, river crossings, and along roadways. The work required acquisition from 36 property owners and permits from 12 federal, state, and local governmental entities.

DuPage Water Commission Transmission System, DuPage County, Illinois—Project Manager for contract administration and construction management for 140 miles of 12- through 90-inch diameter water transmission mains and 2.3 miles of 12-foot diameter tunnel. Associated with this project was the relocation and installation of approximately 45,300 feet of 8- through 48-inch diameter sanitary, storm, and combined sewers including flow control structures and junction chambers.

TW-1 48-Inch Transmission Main, DuPage Water Commission System, DuPage County, Illinois—Design and contract administration for the construction of 8 miles of 48-inch diameter steel water transmission main. This project involved the installation of the pipeline through numerous wetlands, river crossings, and under major expressways.

TW-2 48-Inch Transmission Main, DuPage Water Commission System, DuPage County, Illinois—Design and contract administration for the construction of 10 miles of 48-inch diameter steel water transmission main. This project also involved the installation of the pipeline through numerous wetlands, river crossings, and under major expressways.

TSW-3 48-Inch Transmission Main, DuPage Water Commission System, DuPage County, Illinois—Contract administration for the construction of 9 miles of 48-inch diameter water transmission main, and approximately 9,000 feet of 8- through 30-inch diameter ductile iron and reinforced concrete sewers lines.

TE-3 72-Inch Transmission Main, DuPage Water Commission System, DuPage County, Illinois—Contract administration for the construction of 10 miles of 72-inch diameter steel water transmission main, a 130-mgd metering station, and approximately 24,000 feet of 8- through 64-inch diameter ductile iron and reinforced concrete sewers lines.

Transmission Main Program—City of Jackson Department of Public Works, Mississippi: Program Manager for design of 17 miles of 36- through 60-inch diameter water transmission mains. This work involved the coordination of 12 engineering consultants, two financial advisors, and various other city departments.

Forensic Evaluation, Atlanta, Georgia—Responsible charge for the technical evaluation and contract interpretation associated with the structural failure of approximately 30- through 84-, 96-, and 108-inch diameter butterfly valves. Work included development of in-situ testing of the valves and associated three dimensional finite element analysis to determine cause of failure. Worked with City representatives, attorneys, engineers, and contractors to negotiate the settlement for this structural failure.

Forensic Evaluation, Denver Water, Colorado—Project Manager for technical and field evaluations of the structural failure of two 96-inch diameter butterfly valves. Prepared designs to eliminate the loading conditions causing the excessive valve body deflection.

Project Team

SAMIR F. MATTA, PE
Senior Project Manager

Education:
Masters of Civil Engineering
Wayne State University, 1998

BS, Civil Engineering
Wayne State University 1987

Registration:
Professional Engineer - Michigan - No. [illegible]

Years of Experience:
26

Background
Mr. Matta, P.E., has served as a design, project engineer and/or project manager for numerous design and construction projects in Michigan both as a consultant and as a public employee. He has managed many State and Federal projects for the DTMB, DMVA, USPFO, Corps of Engineers, and other local entities. He also has extensive experience in the design and construction management of various projects that includes Watershed Management, LID design, combined sewer overflow (CSO), sewer rehabilitation, roads and streetscape projects, drainage improvements, water distribution and treatment, environmental cleanup and UST projects.

Related Experience
Flint Water Treatment Plant Expansion, Phase I, Segments 1, 2 & 3, City of Flint, Michigan—Assisted the city in securing $23.5 million dollars in DWRF funding for this project. Another 14 million dollars are anticipated for segments 4 & 5. Phase I - Segments 1 & 2 are currently under construction while the design of phase I – Segment 3 is underway. The overall project is anticipated to be completed within 4 to 6 years period at an estimated cost of $38.0 million dollars for all segments. The project will provide the city with the ability to treat 36.0 million gallons of water to meet maximum day demands of city customers.

Waterford Township Water Treatment Plant, WTP 25-2, Waterford Township, Michigan—Analysis of the addition of new 1,800 GPM well, and new iron removal water filtration system. The project entailed the design of a 1,800 GPM well house, and the addition of water treatment plant expansion to house 3 – 600 GPM high pressure filters to treat well water, and provide iron removal capabilities.

Highland Park Water System Improvements, City of Highland Park, Michigan—Helped the city secure $6.0 million dollars of the State Drinking Water Revolving Fund (DWRF) Loan Program to utilize for distribution and treatment systems repairs. Led the design team in developing construction plans for the replacement of water main, valves and hydrants, water tower, and raw reservoir rehabilitation, and treatment systems upgrades.

West Side Water System Improvements, Lansing Township, Michigan—Analyzed the existing infrastructure yearly needs. Recommended a rehabilitation program that best helps improve the system efficiency, water pressure and fire protection to township residents. Supervised design improvements to upgrade water mains and improve system pressure. Construction Budget: $100,000 - $250,000/year.

Corps of Engineers, Gibraltar Flood Protection Advance Measures Project, City of Gibraltar, Michigan—Project Manager/Lead Project Engineer that led the design team who worked closely with the city and the Corps evaluating flooding potential of areas within the city and developing design plans for pump station facilities and other flood protection measures. The project involved the design of 20 stationary/portable pump stations. Construction Budget: $750,000.

Corps of Engineers, St. Clair Shores Flood Protection Advance Measures Project, City of St. Clair Shores, Michigan—Project Manager/Lead Project Engineer that supervised the evaluation and design of 40 pumping stations to help eliminate the flooding associated with high water level of Lake St. Clair. Worked with the Corps in implementing the construction of the project. Construction Budget: $4,500,000.

Corps of Engineers, Harrison Township Flood Protection Advance Measures Project, Harrison Township, Michigan—Project Manager/Lead Project Engineer that supervised the evaluation and design of 8 pumping stations to help eliminate the flooding associated with high water level of

Lake St. Clair. Worked with the Corps in implementing the construction of the project. Construction Budget: $2,500,000.

US-131 Motorsports Park, Martin, Michigan—Managed the design, permitting and construction of 3.5 miles of 8-inch force main and associated pump station to service the new facility. Coordinated the efforts for the design and permitting with the owner, the Village of Martin, City of Plainwell, Michigan Department of Transportation (MDOT) for the US-131 Crossing and Michigan Department of Environmental Quality (MDEQ). The project was fast tracked and required extensive amount of coordination and communication.

Tecumseh River Pump Station (TRPS) Service Area Sanitary Sewer Evaluation, City of Lansing, Michigan—Project Manager for the evaluation and design of the sanitary sewer system within the service area. The project involves the rehabilitation of the sewer system to eliminate potential infiltration/inflow (I/I) sources and minimize the frequency of sanitary sewer overflows (SSOs) and related basement backups. It also requires an evaluation of the system performance at the end of the construction to determine the effectiveness of the rehabilitation methods implemented.

Webberville System Drainage Improvement Project, Ingham County Drain Commissioner Village of Webberville, Michigan—Project Manager for the evaluation, coordination and design of the storm system infrastructure primarily within the boundary of the Village of Webberville and surrounding Townships. The watershed drainage boundary expands across four drainage districts that services the Village and surrounding Townships. They include: (1) Webberville Drain Drainage District, (2) Webberville #2 Drain Drainage District, (3) Monroe & Leach Drain Drainage District, and (4) Kalamink Drain Drainage District, The project entails the evaluation of the storm sewer system within the four drainage districts and the analysis of Best Management Practices (BMPs) and Low Impact Design (LID) alternatives to address the dysfunctional and poor performance of the existing storm sewer system within those districts. Construction budget $5.5 to $8.0 Million.

Western Trunk Interceptor Phase II Route Study, Genesee County Drain Commissioner's Office—Project Manager for the evaluation of route selection for the extension of proposed interceptor sewer to service the following communities: Mundy Township, Gaines Township, Clayton Township, City of Swartz Creek, City of Flushing and Flushing Township. The proposed 48" to 84" interceptor will extend approximately about 15 miles across the listed municipalities and may require the installation of one or two pumping facilities.

Lake Lansing Road, Wood Street Sanitary Project, Lansing Charter Township, Lansing, Michigan—Project Manager for project which includes design and construction engineering for approximately 4,000 LFT of sanitary sewer extension to service areas along Lake Lansing Road and Wood Street in Lansing Township. The pipe size varies between 8- and 10-inch of extra strength vitrified clay pipe as per City of Lansing Design Standards who services Lansing Township with appropriate sanitary sewer service. The project is broken into two phases to correspond with the road reconstruction project handled by the Ingham County Road Commission Office. Phase I will involve the installation of approximately 2500 LFT of 8- and 10-inch Sanitary sewer lines and associated structures and service leads. While Phase II incorporates the addition of roughly 1500 LFT of 8-inch sewer along Wood Street to tie in to Phase I work. Anticipated project cost for the sewer only is $500,000. The Road Commission work will cover all costs associated with the removal and replacement of new pavement and all restoration work on the project.

Smith-Evans Drain Rehabilitation Project, City of Lansing, Michigan—Project Manager that evaluated drainage districts and erosion control measures for stabilizing the banks of an open drain, which accepts storm flow from an enclosed 84-inch diameter storm sewer pipe. Supervised the design of twin 60-inch enclosed pipe replacement that was approved by the City and the Inter-county Drainage Board.

Combined Sewer System Separation Project, Town of South, Whitley, Indiana—Project Engineer that analyzed the performance of an aged combined sewer interceptor across the centerline of State Route 5 (SR5) and developed hydraulics and consequently separation alternatives for proper drainage of the state highway and other city local streets. The project consisted of new sewer construction, trenchless technology rehabilitation work within residential, commercial and light industrial neighborhoods.

South Perimeter Road Repair Project, Selfridge Air National Guard Base, Mt. Clement, Michigan—Oversaw the evaluation and design of approximately 3 miles of road improvements and miscellaneous utility upgrades. The work consisted of a complete reconstruction of about 2 miles of two lane roadway and combination of pavement overlay and resurfacing of the other one mile. Rehabilitation of a 72" storm sewer was also incorporated into the design improvements.

Project Team

JAMES E. REDDING, PE, LEED® AP
Principal/VP/Director of Engineering

Education
BS, Civil Engineering
Michigan State University, 1978

Registration
Professional Engineer, Michigan, No. 6201029391

Certification
Leadership in Energy and Environmental Design (LEED® AP), 2004

Years of Experience
36+

Background
Jim has more than three decades of professional engineering experience, including two years as assistant city engineer in Bay City, MI. He joined ROWE in 1985 as a project manager and was promoted to principal/chief engineer in 1992. His experience has primarily been focused on water and wastewater projects.

Related Experience
Genesee County Division of Water and Waste Services, Genesee County, Michigan—Water Supply Intake: Project manager responsible for the design, permitting, and construction of $30 million water supply intake. Intake includes construction of 78-inch diameter pipeline installed by tunneling and marine construction into Lake Huron a distance of 8,000 feet (design completed in 2012, construction planned to start in spring 2013).

Torrey Road Booster Pump Station, City of Flint, Michigan—QA/QC for analysis and design of upgrades to water pump station ($1.1M construction; ongoing).

Davis Road Water Main, City of Saginaw, Michigan—Principal in charge for design and construction of one mile of 36-inch water main including analysis of pipeline materials and critical schedule (2007).

Water Booster Pumping Station, City of Saginaw, Michigan—Project manager for upgrades to water booster pumping station to increase capacity from 0.7 mgd to 2.3 mgd. Two existing pumps were replaced with larger ones and a third pump was added. The project included reworking piping to accommodate the pumps, SCADA, backup power generation, and building upgrades.

Wastewater Treatment Plant Analysis/Upgrades, City of St. Louis, Michigan—Project manager for the analysis and preliminary engineering for a 4 mgd treatment plant modifications. The existing RBC treatment plant does not reliably meet NPDES permit limits and peak flow conditions cause backups in the disinfection tank and final clarifiers. Flows and loading conditions have been analyzed to identify alternatives for providing treatment to the permitted limits. Hydraulic model of the plant facilities was developed to determine the cause of the backups, and alternatives have been developed for correction. A project plan has been developed to secure SRF funding for the project. A new oxidation ditch has been designed along with upgrades to other facility processes (2013).

Potable/Non-potable Water Supply Survey, Oklahoma City Veterans Affairs Medical Center,(Oklahoma City, OK), Accord Architects & Engineers, Myrtle Beach, South Carolina—Principal in charge of development of an emergency water plan for the facility. The facility had experienced water shortages in the past and hired Accord Architects & Engineers and ROWE to research the existing onsite water supplies and the city water supply. The team reviewed the water supply per VA design guidelines, reviewed the reliability of the city system, developed options and costs for improving the reliability of the onsite system during a water shortage, and worked with the VAMC staff to prioritize and minimize water usage in case of a water outage (2012).

Water Treatment Plant, City of Caro, Michigan—Principal in charge of three-mgd treatment plant and new wells. Treatment plant provides removal of arsenic and iron (DWRF; 2005).

New Well, City of Caro, Michigan—Project manager for construction of new well and water main to provide water supply for ethanol facility (CDBG grant; 2005).

Project Team

RANDAL C. HILL, PE
Senior Project Manager

Education:
BS, Civil Engineering,
Colorado State University, 1975

Registration:
Professional Engineer, California, No. [illegible]

Years of Experience:
37

Background
Mr. Hill has over 37 years of diversified experience on water conveyance and water treatment projects involving pumping facilities, pipelines, reservoirs, tunnels, flow control facilities, bidding services, site development and right-of-way acquisitions, treatment facilities, coordination on environmental issues, feasibility studies, facility plans, aerial and topographic surveys, and construction support services.

Related Experience
Advanced Water Purification Demonstration Plant, City of San Diego, California—Mr. Hill served as project manager for design, construction, and operation for this high profile, state-of-the-art project to develop another sustainable source of water for the City's long-term water demands. The water purification process used a multi-barrier approach consisting of micro and ultra-membrane filtration, reverse osmosis and advanced oxidation utilizing ultraviolet light with hydrogen peroxide. This $6,600,000 project with a 1 million gallon per day capacity is being operated to demonstrate that a new local water source is safe, reliable, cost-effective, and can be produced in an environmentally sensitive manner for a full scale system. The project design and construction were completed on schedule and costs were under budget.

Large-Diameter Steel and Yard Piping, 100-million-gallon per-day (mgd) Twin Oaks Valley Water Treatment Plant (WTP) Design-Build-Operate Project; San Diego County Water Authority, San Diego, California—Mr. Hill served as design manager of the large-diameter (42- to 96-inch) steel pipelines and yard piping for this $150 million state-of-the-art facility that will be the largest membrane ultra filtration (UF) facility in the world. This facility employs UF membrane filtration, ozonation for disinfection, advanced oxidation for taste and odor control; and biological activated carbon contactors. It is being delivered under a very aggressive schedule and embodies all the benefits of design-build in terms of flexibility, responsiveness, schedule, and cost-efficiency.

Quality Control/Quality Assurance Engineer, Brawley Water Treatment Plant (WTP), Brawley, California—For the City of Brawley, Mr. Hill performed quality control reviews on final design phase engineering of a 10,500-gpm raw water pump station and 16,000-gpm/13,000-gpm finished water/wash water pump station. The raw water pump station included four vertical diffusion vane pumps; two with variable-speed drives. The finished water/wash water pump station included eight vertical diffusion vane pumps to serve two pressure zones; two pumps had variable-speed drives. He performed design including inlet/outlet piping design, operational considerations, pump and control valve design, and preparation of construction drawings and specification. Coordinated work with WTP including civil, structural, and electrical disciplines.

White Rock Treatment Plant Improvements, Dallas, Texas—For the City of Dallas, Mr. Hill prepared preliminary design report and coordinated design efforts for $8.2 million of hydraulic improvements to a 100-mgd WWTP. Improvements included new raw sewage pumps, sludge pumps, recirculation pumps, addition of four secondary clarifiers, and modifications to plant piping.

Jasper Street WTP Improvements, Wichita Falls, Texas—For the City of Wichita Falls, Mr. Hill directed design and preparation of contract documents for flocculation and sedimentation basin equipment, filter media and under drains, filter control system, wash water tank, chlorine and ammonia feed systems, chemical feed system and the addition of high service pumps.

San Dieguito Water District/ Santa Fe Irrigation District 3, 4, 5, and 6 Flow Control Facilities, Rancho Santa Fe, California—For San Diego Water Authority, Mr. Hill managed and directed design efforts for new flow control facilities consisting of four flow meters to meter 84 cfs of raw water and 42 cfs of treated water to the Badger Filtration Plant. Work included site layout, architectural, mechanical, electrical, and instrumentation design.

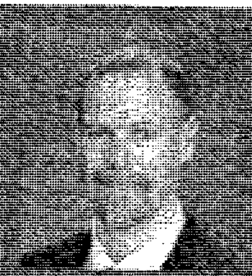
Project Team

Jeffrey R. Hansen, PE
Senior Project Manager

Education
BS, Civil Engineering,
Michigan State University, 1996

Registration
Professional Engineer, Michigan No. [illegible]

Years of Experience
18



Background
Mr. Hansen has extensive experience providing design and construction services for a variety of municipal for a variety of municipal systems, facilities, and drinking water systems including supply, wells, storage, pumping, water main design, water treatment design and water system modeling.

Related Experience
Bay Area Surface Water Treatment Plant Evaluation, SMMWSC, Michigan—Mr. Hansen completed a preliminary engineering report for surface water treatment plant (WTP). The report evaluated treatment technologies, multiple WTP site locations, environmental and site considerations, transmission main routings, reliability, emergency water supply alternatives, and costs.

Bay Area Surface Water Treatment Plant Project Plan, Bay County Department of Water and Sewer, Michigan—Mr. Hansen completed a water treatment plant (WTP) Project Plan for low interest funding through the Drinking Water Revolving Fund (DWRF) program. The Project Plan met the requirements of the Michigan Department of Environmental Quality (MDEQ) and qualified the Owner for $6 million in grant money in addition to low interest loan funding.

Flint Water Treatment Plant Improvements, City of Flint, Michigan—As a Project Engineer, Mr. Hansen assisted with a preliminary engineering report, funding application, and design for water treatment plant improvements.

Highland Park Water Treatment Plant Improvements, Flint, Michigan—As a Project Engineer, Mr. Hansen has assisted with a preliminary engineering report, funding application and design for water treatment plant improvements for the City of Highland Park.

Sims Bayou Water Storage Tank Improvements, City of Houston, Texas—Mr. Hansen served as Project engineer for new overflow weir structures and overflow pipes for four ground storage tanks. Project also included site drainage evaluation.

Katy Addicks Pump Station, City of Houston, Texas—Mr. Hansen served as Project Engineer for 1200 linear feet of new 42-inch steel water line.

Lake Huron Water Supply Initiative, Genesee County Drain Commission, Department of Water And Waste Services, Michigan—Mr. Hansen was the local Project Manager for the design of two lake intake cribs, intake pipeline, and shorewell as the first step in developing a new water supply system. The project included two 60-mgd intake cribs, 78-inch PCCP / steel intake pipe, stop log chambers, pipeline manways, tunneling, HDPE chemical feed piping for zebra mussel control, secant pile wall shorewell / junction chamber and associated appurtenances including a 78" x 78" sluice gate.

US290 / 12th Street Water Main Casing Extension, City of Houston, Texas—Mr. Hansen served as Project Manager for a water main extension of approximately 600 linear feet of split steel casing to be installed on an existing 72-inch water transmission line to allow for highway widening.

Iron and/or Arsenic Removal Water Treatment Plants Design, Multiple Locations—Mr. Hansen has designed numerous arsenic and/or iron removal plants for both public and private organizations with new wells, chemical feed, new housing, above and below ground piping, retrofitting of existing systems, planning for future expansion, etc. Projects have included clients such as the City of Perry, Village of Dryden, Village of Fowler, City of Memphis and Brandon Schools.

Iron Removal Water Treatment Plants Construction Management, Multiple Locations—Mr. Hansen managed construction of Arsenic and/or Iron Removal Water Treatment Plants for the City or Perry, Village of Dryden, Village of Fowler and City of Memphis. Each project included separate bid packages for individual disciplines and therefore required involved management by Mr. Hansen to coordinate efforts between numerous contractors.

Booster Pump Station, Muskegon Township, Michigan—As the Project Engineer, Mr. Hansen designed a booster station with three 200 HP (3900 gpm) pumps and a 1-MG ground storage tank for Muskegon Township.

Water CADD Models, Multiple Locations—Mr. Hansen developed working WaterCADD models of many water systems such as St. Johns, Highland Park and South Bend, IN.

Water Treatment Plant Projects, Multiple Locations—As a Project Engineer, Mr. Hansen has assisted with water treatment plant projects for the City of Flint and the City of Highland Park.

Green Oak Township Water Needs Assessment, Green Oak Township, Michigan—Mr. Hansen valuated future water demands and developed water system plan in order to assist the Township with future planning and decision making with the acquisition of a developer owned well.

New Well And Village Wide Water Meters, Village Of Ubly, Michigan—Provided design services / construction plans for a new well, well house, water main, well abandonments and new individual water meters to convert to a metered customer base. The project was funded through the MDEQ – DWRF low interest loan program and allowed the Village to provide low arsenic water for the community.

Water Supply Study, City Of Perry, Michigan—Mr. Hansen completed a study to analyze options for a new well field. The analysis evaluated alternatives including site location, capacity concerns, treatment implications, compatibility with the existing water system and expected costs.

Waste Water Treatment Lagoons, City Of Perry, Michigan—Project Manager for rehabilitation of waste water treatment lagoons including installation of a liner system, rip rap bank erosion protection and SolarBee aerators / mixers. Mr. Hansen completed a project plan allowing the City to obtain funding, both grant and low interest loan, through the MDEQ – State Revolving Fund.

New San Juan Diego Activities Center, Our Lady Of Guadalupe Catholic Church, Michigan—Mr. Hansen worked in cooperation with THA Architects to provide design of a new Activities Center and the associated site work. Mr. Hansen was responsible for grading, parking lot improvements, new sanitary and water services, site drainage system with detention pond, soil erosion control, landscaping, and permitting.

New High School, Lake Fenton Community Schools, Fenton, Michigan—Mr. Hansen worked with THA Architects to provide site design of grading, utilities, roadways, sidewalks, drainage and parking lots. Project included multiple phases, on site wells, and athletic fields.

U.S. 23 Wetland Mitigation and Design, Michigan Department of Transportation, Ogemaw County, Michigan—Modeled existing and proposed wetlands at a yearly run time in order to maximize the proposed replacement wetland.

Glycol Runoff Collection, Capital Region Airport Authority, Lansing, Michigan—Project engineer for system to collect runoff containing glycol and divert to detention pond. Pond designed to pump to sanitary sewer or drain to open channel.

Smith - Evans Storm Drain, City of Lansing, Michigan—Project engineer for nine hundred feet of open channel conversion into a two-barreled, 5-foot HDPE underground piping scheme. Required system modeling using XP-SWMM software.

Dryden Road Reconstruction (West), Village Of Dryden, Michigan—Mr. Hansen provided design and construction engineering for reconstruction of Dryden Road from Union Street to the west Village limits. The project was designed and constructed in accordance with MDOT specification and requirements.

Project	Budget	Final Construction Total	% Under Budget	% MDEQ Milestone
Ubly Well & Water Meters	$455,000	$451,679	0.7%	100%
Dryden WTP	$819,000	$694,868	15.1%	100%
Fowler WTP	$982,800	$755,855	30.0%	100%
Perry WTP	$1,609,000	$1,564,700	2.8%	100%
Perry WWTL	$2,775,000	$2,748,368	1.0%	100%

Project Team

Jeremy N. Nakashima, PE
Senior Project Manager

Education
MS, Civil Engineering (Geotechnical), University of Illinois, 199[illegible]

BS, Civil Engineering (Environmental), University of Illinois, 1994

Years of Experience
18

Registration
Professional Engineer, Michigan, No. [illegible]

Background
Jeremy N. Nakashima is experienced in water and wastewater facility and system planning, engineering, and program management. Mr. Nakashima has been responsible for all aspects of a project from conception through construction. He has overseen the design and construction of numerous water supply, treatment and distribution facilities for municipal and private utility clients throughout the U.S.

Related Experience
Bay County Water Treatment Plant, Saginaw-Midland Municipal Water Supply Corporation (SMMWSC) & the Bay County Department of Water and Sewer, Michigan—The SMMWSC and the Bay County Department of Water and Sewer retained LAN to prepare a preliminary study for the feasibility of locating a 20-mgd surface WTP in the Bay Area to provide finished water to numerous municipal customers. The study included preliminary design of the WTP and associated water system facilities, evaluation of multiple WTP site options, development of various alternatives for secondary supply, and development of a detailed cost analysis. The report was prepared in accordance with the MDEQ requirements for use in applying for a Drinking Water Revolving Fund low interest loan. Mr. Nakashima's responsibilities included the evaluation of existing low and high service pumps at the Bay City WTP for possible reuse in one of the project alternatives, as well as performing QA/QC reviews of the preliminary engineering report.

New Water Treatment Plant, Village of Mahomet, Illinois—Project Manager for multi-million dollar water treatment plant improvements that tripled plant capacity to meet the demand of a growing community. Design of the new 1,800 gpm plant includes the addition of two new 600 gpm package iron removal units for aeration, detention and filtration; four new 9-foot diameter ion exchange softeners; a new softener building; new high service pumps; chemical feed systems; converted brine storage tank; converted backwash wastewater holding tank; a new backwash wastewater pump station; upgraded electrical service, emergency power systems and instrumentation; and miscellaneous site improvements.

Surface Water Intake, Division of Water and Waste Services, Genesee County Drain Commissioners Office, Genesee County, Michigan—Mr. Nakashima served as Assistant Project Director for design engineering services of a new water supply intake system. Located on the western shore of Lake Huron at the county line between Sanilac and St. Clair counties, the new 85-mgd water supply intake system consists of: two 48'x48' octagonal intake structures (timber cribs); 6,575 LF of 78-inch intake pipeline; 300 LF of 60-inch intake pipeline; two submerged steel stop log chambers on the intake pipeline for crib isolation; a 35-foot diameter, 57-foot deep onshore junction chamber for tunneling operations; and a zebra mussel control system. Mr. Nakashima was responsible for overall QA/QC of the bidding documents, assisted in design coordination between subconsultants and prime consultant, and prepared several project specifications and drawing details related to the junction chamber, stop log chambers, intake pipeline, and timber cribs. In particular, he was responsible for the design of the zebra mussel control system, including performing hydraulic calculations for the chlorine solution piping and diffuser design, selection of materials and design details.

Lexington Pumping Station Generator Facilities, DuPage Water Commission, Elmhurst, Illinois—Project Engineer for the design of a new generator building and generator electrical building at the Lexington Pumping Station and Reservoir. Responsibilities include the design of the relocation of existing site utilities necessary for the construction of the new facilities. Utilities requiring relocation include a 36-inch watermain, sanitary and storm sewers, electrical ductbanks and gas mains. During the construction phase, Mr. Nakashima served as Project Manager responsible for all construction-related engineering services.

New Ammonia Feed System, City of Houston, Texas—Mr. Nakashima was responsible for the preliminary design, final design, and preparation of construction documents for a new Liquid Ammonium Sulfate chemical feed system for chloramine disinfection at the West Houston #3 groundwater treatment facility which included: 1) bulk chemical storage in an outside secondary containment structure sized for a minimum storage of 15-days; 2) new building to house the chemical feed system and electrical with a separate equipment room for four liquid vacuum feed systems, day tank, dual wall containment piping, gas monitoring system, and a separate control room for electrical, instrumentation and SCADA; and 3) sizing of the chemical feed system and storage facilities were based on a maximum plant capacity of 6.7-mgd.

Green Bay Water Utility, Green Bay, Wisconsin Lake Pumping Station Improvements, Contract D—Project Engineer for the design of improvements to the raw water Lake Pumping Station, which includes the phased construction of replacement of the five existing 8-mgd vertical split case centrifugal pumps with five 9-mgd vertical turbine pumps. The project includes modifications to the existing wetwell and drywell suction and discharge piping to accommodate the new pumps, as well as wetwell structural modifications.

Green Bay Water Utility, Green Bay, Wisconsin Lake Pumping Station Improvements, Contract E, 42" Discharge Header Replacement—Served as Project Manager providing construction engineering services, including review of submittals, RFI's, contractor pay requests, change orders, as well as construction observation services, for improvements at the raw water Lake Pumping Station for the Green Bay Water Utility. The project includes modifications to the pumping station discharge header and replacement of a section of an existing 42-inch transmission main with approximately 470 lineal feet of new 42-inch buried steel pipeline. Work also includes modifications to the interior discharge piping, installation of a new 30-inch butterfly valve with electric motor actuator, construction of a new surge relief valve vault, new 16-inch surge piping, new air release and access vaults, new cathodic protection test stations, 42-inch steel pipe connection to existing 42-inch PCCP, new station water piping, relocation of chlorine vacuum lines, new access drive, and miscellaneous site improvements.

Reservoir Groundwater Control Project, Green Bay Water Utility, Green Bay, Wisconsin—The Green Bay Water Utility (GBWU) owns, operates, and maintains one 4 MG and two 2 MG finished water below grade reservoirs at the Filter Plant facility. In an effort to comply with the Wisconsin Department of Natural Resources code regarding allowable groundwater conditions at below grade reservoirs, the GBWU retained LAN to develop a plan and construction documents to lower the groundwater level at the existing reservoirs. Mr. Nakashima served as Project Engineer for the final design of the groundwater dewatering system which consisted of a series of French drains, manholes and pumps to lower the local groundwater table around the reservoirs. He also was responsible for QA/QC of the construction documents.

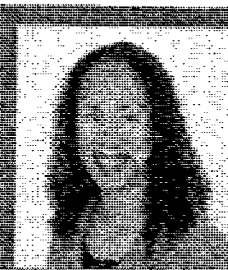
Junction Pumping Station Improvements, Saginaw-Midland Municipal Water Supply Corporation, Bay City, Michigan—Project Engineer responsible for general construction administration for improvements at the Junction Pumping Station, which included the construction of a new maintenance building, 48-inch and 60-inch reservoir and transmission main piping, valve vaults and miscellaneous site improvements. Duties included submittal review, pay request and change order processing, and general coordination with the Owner and Contractor.

Hydraulic Improvements, Metropolitan Water Reclamation District of Greater Chicago, Illinois—Project Engineer for the final design of three new diversion chambers and large process piping outside of the new 480-mgd High Level Influent Pump Station at the Calumet WRP. Responsible for completing project plans and specifications for the diversion chambers and piping, as well as coordination with other design disciplines and subconsultants. Use of the Calumet WRP MUPPS mapping was instrumental in the final design of the diversion chambers and process piping as it illustrated the extensive and complex underground utilities and structures that have been constructed throughout the history of the treatment plant. Use of the Calumet WRP MUPPS database was useful in identifying contract drawings when details of existing utilities and structures were needed for the final design of the diversion chambers and piping. During the construction phase, Mr. Nakashima served as Project Manager responsible for all construction-related engineering services.

Water Treatment Plant Rehabilitation, Village of Buckley, Illinois—Village Engineer and Project Manager for the design and permitting for the complete rehabilitation of the existing water treatment plant including the refurbishment of the aeration/detention tank and the replacement of the high service pumps, pressure filters, and ion exchange softeners. This project was funded in part by an IEPA low interest loan.

Project Team

Melissa C. Henderson, PE
Associate, Project Manager



Education:
BS, Mechanical Engineering,
Massachusetts Institute of Technology, 1997

MS, Hydrology for Environmental Management,
Imperial College of Science,
Technology & Medicine, 2000

Years of Experience:
16

Registration:
Professional Engineer, Michigan, No. [illegible]

Background
Melissa Henderson is LAN's lead engineer on hydraulic and transient modeling with extensive experience in water system hydraulic analysis. Her experience includes water system analysis using EPANET, InfoWater, WaterCAD and WaterGEMS, and transient analysis using the Liquid Transient (LIQT) program.

Ms. Henderson has performed analyses of numerous water, storm and sanitary systems to develop and update utility master plans, water supply feasibility studies, and has been involved in route evaluations, design of water and sanitary mains, population and water demand projections, demand allocation, and hydraulic and transient analysis of water and sanitary treatment plants and associated facilities. Ms. Henderson has developed and calibrated extended-period simulation hydraulic models to analyze existing infrastructure facilities and their operation, identify system deficiencies, optimize supply management, and determine system improvements.

Related Experience

Model Development, Saginaw-Midland Municipal Water Supply Corporation (SMMWSC), Bay City, Michigan— Ms. Henderson was the leading hydraulic modeler and project engineer for this project, which included creating a hydraulic model for SMMWSC and provided training to allow Saginaw-Midland personnel to perform hydraulic analyses using the model. As part of this effort, an extended-period simulation hydraulic model for the current system will be created utilizing either the U.S. EPA's EPANET software. The developed hydraulic model will be calibrated with historic field data. As part of the effort, Ms. Henderson is leading the data collection and review; set-up of the model, development of demand patterns and calibration of the model. She will also develop a model manual that provides detailed information regarding the model created and data used, and serves as a guide for performing hydraulic analyses.

Lake Shore Pump Station and Associated Raw Water Transmission Mains Transient Analysis, Green Bay Water Utility (GBWU), Wisconsin—Ms. Henderson was the project engineer overseeing the transient analysis of the GBWU Lake Shore Pump Station and associated transmission mains. Her team created a detailed transient analysis model utilizing LIQT software that included the Lake Shore Pump Station (LSPS), the 42-inch and 54-inch transmission lines beginning at the LSPS, the surge protection devices located along the transmission lines and at the LSPS and Booster Pump Station (BPS). The team also developed boundary conditions were also determined for the discharge at the Water Filtration Plant where the two transmission lines terminate. Based on the transient analyses results, Ms. Henderson and her team provided several conclusions and recommendations to GBWU. Analyses confirmed the existing normal and emergency operating procedures, surge protection devices and check valves all serve to protect the LSPS discharge header and connected transmission lines from excessive surge pressures and vacuums. Her team also identified and recommended continued operation of key surge protection devices to maintain sufficient surge protection within system along with additional recommendations for normal pump start-up, normal pump shut down and emergency conditions.

West Harris County Regional Water Authority (WHCRWA) Surface Water Master Plan, Harris County, Texas—Ms. Harrison is currently involved in the development of a "Master Plan" for the surface water infrastructure necessary to supply the 226 square miles for the WHCRWA, which is located in Western Harris County outside the City of Houston. As part of this project, she calculated the total water demand using the University of Houston's Center for Public Policy Census Tract population projects, 2000 Pumpage data, and supplemental data regarding water usage from the WHCRWA Municipal Utility Districts (MUDs). Ms. Henderson allocated population and water demand for each of the 107 MUDs and areas within WHCRWA not within a MUD. She evaluated proposed surface water pipeline routes. Ms. Henderson evaluated costs and analyzed financial alternatives for the proposed surface water system.

Project Team

Melissa C. Henderson, PE, Continued

She analyzed system curves for proposed pumps, performed preliminary pump and motor selection and determined the preliminary plant layout for pumps. Estimated construction cost $483,750,000.

78-inch Transmission Main, Segment 1, Brushy Creek Regional Utility Authority (BCRUA), Cities of Cedar Park, Leander and Round Rock, Texas—Ms. Henderson worked as the lead project engineer for the transient hydraulic modeling of the proposed BCRUA Segment 1 Transmission Main. Ms. Henderson and her team performed transient hydraulic analysis for all BCRUA transmission main design teams. Ms. Henderson led the development of a transient model for the BCRUA utilizing preliminary alignments. Ms. Henderson assessed the system under both normal operating and failure conditions. Ms. Henderson also conducted analyses to determine the impact on the transmission system of the flow control valves at the various take points. Based on the results of the transient modeling, Ms. Henderson determined the anticipated transient pressures and required appurtenances for transient pressure relief. Ms. Henderson provided a technical memorandum of the results of the transient analysis, which included the assumptions used in the model, transient pressures anticipated along the alignment, and a table of recommended appurtenances including location and type. Transient Hydraulic Analysis was to be performed at 60% and 90% for all designs. In addition, Ms. Henderson designed the air release valves including size, location, and type of valve needed for draining, filling, and air release functions (not related to surge). Air release valves will be designed utilizing AWWA M51 and appropriate information from vendors. Ms. Henderson also reviewed the standard Air Release Valves details for the transmission main design projects.

West Harris County Regional Water Authority (WHCRWA) Water Pump Station No. 1—WHCRWA, City of Houston, Texas: Ms. Henderson developed booster pump station layouts for two phases of development for the WHCRWA's Water Plant No. 1 to delivered treated surface water. In addition to providing conceptual booster pump station layouts, she also provided preliminary pump selection recommendations based on the system's Phase 1 and Phase 2 flow and pressure requirements. Ms. Henderson's analysis of Water Plant No. 1 included hydraulic modeling of the WHCRWA surface water transmission system and an evaluation of normal pump start-up and shutdown, and pump failure scenarios for transient surge conditions.

Green River Pumping Plant Project, Transient Analysis, Franson Civil Engineers, Unitah County, Utah—Ms. Henderson was the lead project engineer and transient modeler responsible to perform a transient analysis to support the proposed pump station and the 42-inch raw water line design, known as the "Green River Pumping Project" (GRPP). She led a transient modeling team that performed analyses using the LIQuid Transient, also known as LIQT program. Four major operating conditions were modeled, with comparison between the use of a surge anticipator valve (SAV) and a surge tank (ST). Two different pump manufacturers were also compared, American-Marsh and National pumps. Additionally, two control valves were analyzed in conjunction with the type of surge protection utilized. Ball valves were utilized in the SAV scenarios and butterfly valves (BFV) were analyzed in the ST scenarios. An analysis of the transient conditions in the proposed pump station and proposed 42-inch pipeline was performed for pipeline filling, pump start-up, pump shut-down and power failure. Based on results of the modeling scenarios, recommendations were made regarding the type and location of surge protection devices to adequately protect the system in the event of a transient occurrence.

Mt. Carmel Water Treatment Plant (WTP) to Hillcrest Ground Storage Tank (GST) Water Transmission Line Design, City of Waco, Texas—Ms. Henderson assisted with the hydraulic modeling efforts related to the proposed transmission main from the Mt. Carmel WTP to the Hillcrest GST. Based on recent meetings with City staff, she investigated the impacts of tying the proposed transmission main into an existing 12-inch distribution line and converting the existing 16-inch Hillcrest GST refill line into a transmission/distribution main. Ms. Henderson also performed analyses to verify the size of the proposed Mt. Carmel to Hillcrest transmission main.

Surface Water Transmission System Design, City of Sugar Land, Texas—Ms. Henderson served as the senior hydraulic engineer to perform a hydraulic analysis and transient modeling services related to the City's proposed surface water transmission main system, which included a 22-mgd Surface Water Treatment Plant (SWTP) and transmission waterlines ranging in diameter from 16- to 36-inches.

HCFWSD 61 - WWTP No. 2 - Hastings Green, Harris County FWSD No. 61, Texas—Ms. Henderson reviewed previous hydraulic calculations for the Hastings Green Waste Water Treatment Plant No.2 (Hastings Green). In addition, she updated the plant's hydraulic model to determine cause of poor performance at the plant. Standard hydraulic equations were used to develop the plant's hydraulic profile and calculations were performed in Microsoft Excel.

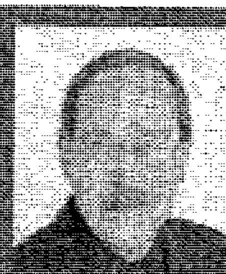
Project Team

Denney R. Howard, PE
Chief Electrical Engineer

Education:
BS, Electrical Engineering,
Texas Tech University, 1981

Registration
Professional Engineer, Michigan, No. 6201057532

Years of Experience
30



Background
Mr. Howard has more than 29 years of experience in the engineering design field of electrical, controls, instrumentation, and site electrical utility systems. Mr. Howard's electrical design background includes water and wastewater utility facility projects which incorporates utility coordination, medium-voltage and low-voltage distribution systems, standby and emergency power distribution systems, computer-aided power system coordination studies, grounding and surge protection systems, SCADA and telemetry systems, instrumentation and control systems interior and exterior lighting systems, fire alarm and security systems, and lightning protection systems.

Related Experience
Red Bluff Water Treatment Plant Upgrades, Coastal Water Authority (CWA), Pasadena, Texas—CWA has asked LAN to implement five of the seven projects identified in the preliminary engineering report (PER). LAN developed detailed drawings and specifications and provided bid and construction phase services for the projects, which included adding a fourth 22-ft.-diameter filter with all piping, power, valves and controls; replacing three other 22-ft. diameter filters, its 120-V power supply, automatic controls and control panels; replacing numerous pieces of non-functional equipment; replacing the existing manual chlorine gas system with an automated sodium hypochlorite dual-feed system and installing new pump systems for the chemicals; and designing a new SCADA system to fully integrate all existing control functionality and new improvements. Mr. Howard provided all electrical engineering design for the distribution system and conducted quality assurance and quality control (QA/QC) reviews of the SCADA and instrumentation and controls designs.

Water Treatment Plant Study and Improvements, City of Lubbock, Texas—As Lead Electrical Engineer, Mr. Howard provided electrical, instrumentation, control, and SCADA systems tasks, which were integrated in the overall plant evaluation and energy audit. Mr. Howard supervised a plant power system study that included short-circuit and load-flow analysis, protective device coordination and arc-flash study and electrical system condition assessments. He also supervised an energy audit of the electrical, HVAC, and pumping systems. Mr. Howard was also engaged with the City to implement recommendations from this study. Improvements included replacement of the plant's service entrance switchgear with 2,000-A/480-V main-tie-generator-tie-main draw-out switchgear, additional electrical distribution system equipment, lighting systems with energy-efficient systems, HVAC systems with energy-efficient systems, motors with energy-efficient motors, and SCADA system with a state-of-the-art system that provided a more user-friendly interface.

Water Treatment Plant Preliminary Engineering Report (PER), Coastal Water Authority, Pasadena, Texas—Mr. Howard provided electrical engineering for the preparation of a PER for proposed improvements to the Red Bluff WTP including installing a new gravity filter, replacing the existing chlorine system with a sodium hypochlorite feed system, implementing a new SCADA system to replace the timer and relay-driven master control panel, and replacement or upgrades to various system components that or no longer functioning or are obsolete.

Saginaw-Midland Municipal Water Supply Corporation (SMMWSC) Whitestone Point Pumping Station Variable Frequency Drive (VFD) Feasibility Study, Augres, Michigan—As lead electrical engineer, Mr. Howard provided SMMWSC a preliminary design report (PER) investigating the feasibility of adding VFDs to the Whitestone Point Pump Station in order to save energy while improving operational capabilities. Whitestone Point is located on the western shores of Lake Huron in Michigan. The pump station was constructed in 1946 with three 1,200-hp pumps equipped with 2,400-V synchronous motors. From 1965 through 1994, five 2,500-hp pumps were added. During preparation of the report, LAN investigated available VFD manufacturers, existing motor compatibility with VFDs, electrical distribution modifications, control system modifications and HVAC system modifications potential energy savings. LAN and

SMMWSC found that adding VFDs to two 1,200-hp pumps and discontinuing the use of flow-control valves for the same pumps, would save SMMWSC approximately $114,000 per year, which would pay back the investment in 6.5 years. Following the PER, Mr. Howard assisted SMMWSC in the procurement and installation of two 1200-hp medium-voltage VFDs and the main 5-KV switchgear.

Capacity Evaluation Study, Coastal Water Authority (CWA), Pasadena, Texas—LAN completed a capacity evaluation for the Red Bluff WTP in an effort to determine and compare the original design capacity against the actual capacity of the plant at existing conditions. The study then identified and examined immediate and future improvements required to deliver upon CWA's contractual agreements and then determined the plant's ultimate site capacity. Mr. Howard evaluated the existing electrical service and distribution; visually inspected electrical panels, pumps, sensors and other systems; made recommendations for further infrared inspection of aging electrical systems; and evaluated potential equipment locations for future expansion of the plant and/or addition of electrical systems.

Southwest Pump Station and Ground Storage Tank, Lubbock, Texas—As lead electrical engineer, Mr. Howard supervised the design of low-voltage power, instrumentation and control, lighting and fire alarm systems for a new 14-mgd water pumping station serving the western portion of the City of Lubbock and Lubbock County. The design included coordination with Lubbock Power and Light to provide electrical service to the facility. Since this facility needs to remain in service during emergency events, the facility was designed with a large, 1,200-kW, standby diesel-engine generator set. The design also included two 150-hp, medium-voltage variable frequency drives (VFD) and two 250-hp, medium-voltage solid-state drives. Mr. Howard also provided the design of the instrumentation, control and SCADA systems for the pump station. The SCADA system incorporated a radio telemetry system to allow the pump station to communicate with the City's existing SCADA communication system.

City of Rosenberg WWTP No. 2 Expansion and Improvements, Rosenberg, Texas—Expansion and improvement of the City's existing 3-mgd WWTP increasing the plant's current average daily flow (Qadf) capacity from 3-mgd to 4.5-mgd and its 2-hour peak flow (Qpk) rate from 9-mgd to 18-mgd. Mr. Howard served as the senior electrical engineer for the project. In particular, his role involved the electrical, instrumentation and controls design for all of the proposed treatment components, as well as specification development, code compliance, project detailing, calculations and coordination with other design disciplines, which included the on-site lift station, headworks, aeration splitter box, new and existing aeration basins, aeration blowers, clarifier splitter box, new clarifier No. 3, RAS/WAS pump station, scum pump station, selected disinfection system, NPW system, rotary drum thickener, aerobic digester basins and digester blowers. In addition, Mr. Howard designed new process control panels, six additional motor control centers (MCC), new power distribution switchboard, automatic transfer switch and auxiliary 2,000-kVA generator. Finally, Mr. Howard participated in submittal reviews during the course of the project's construction phase.

WWTP No. 1 Expansion and Improvements, Killeen, Texas—Mr. Howard served as the lead electrical engineer for the Bell County Water Control and Improvement District No.1 South WWTP project, which involved the design and construction of a new 6-mgd average daily flow facility, with a corresponding 2-hour peak flow of 18-mgd.

In particular, Mr. Howard was responsible for the electrical design for all of the new process components, which included the headworks fine screening and grit removal, sequencing batch reactor, disc filtration, ultraviolet (UV) disinfection, aerobic digesters, belt press dewatering, and effluent pump station. In addition, Mr. Howard's efforts included provisions for an emergency stand-by generator system, sized to support the full forward flow of the new treatment plant.

Chisholm Trail-Legend Oaks Highway 29 Pump Station - Georgetown and Austin, Texas—As lead electrical engineer, Mr. Howard supervised the design of low-voltage power, instrumentation and control and lighting systems for a new 7.8-mgd water pumping station serving the a suburban area north of Austin. The design included coordination with Georgetown Electrical Cooperative to provide electrical service to the facility. Since this facility needs to remain in service during emergency events, it was designed to allow connection of a portable 500-kW, standby diesel-engine generator set. The design also included two 250-hp, medium-voltage variable frequency drives (VFD) and two 250-hp, medium-voltage solid-state drives. Mr. Howard also provided the design of the instrumentation, control and SCADA systems for the pump station. The SCADA system incorporated a radio telemetry system to allow the pump station to communicate with the Chisholm Trail Special Utility District's existing SCADA communication system.

Project Team

MEREDITH G. MCCULLOUGH, PE
Engineer IV

Education:
MS, Environmental Engineering,
Texas Tech University, 2005

BS, Environmental Engineering,
Texas Tech University, 2003

Years of Experience:
9

Registration:
Professional Engineer, Texas No. [illegible]

Background
Ms. McCullough provides engineering for water and wastewater facilities and utility systems. She is an expert in water/wastewater system modeling and infrastructure planning.

Related Experience

A.R. Davis Water Treatment Plant Filter Process Improvements and Valve Replacement, City of Austin, Texas—LAN provided engineering services to the filtering system and recommending modifications to enhance the performance in the filter pipe gallery. Ms. McCullough was involved in the design of the replacement of 162 large-diameter valve and actuators for 27 dual media filters. Additionally, she provided construction phase services responding to construction submittals, RFIs, and general engineering support for the construction phase of this project.

Filter Improvements Project, Schertz-Seguin Local Governmental Corporation (SSLGC), Nixon, Texas—Ms. McCullough designed a filter rehabilitation project for the SSLGC WTP. This project included the replacement of four (4) pressurized filter media, protective coatings and interior air scour piping and nozzles. Additionally she, preformed construction management on this project managing contractor pay applications, on-site inspection of blasting and painting, change orders and miscellaneous construction activities.

Robinson Water Treatment Plant Improvements Project, City of Robinson, Texas—Ms. McCullough was the Project Engineer for the design on a 500,000 million gallon Clearwell, pump station relocation, and yard piping improvements for the Robinson water treatment plan. The project involved groundwater uplift design and continued plant operations considerations for the Clearwell construction. She developed plans and specifications for this project.

Water System Hydraulic Modeling, Brushy Creek Regional Utility Authority (BCRUA), Cedar Park, Texas—Ms. McCullough evaluated the preliminary operations and hydraulics of the booster pump station, storage tanks, and transmission main for the BCRUA WTP. The hydraulic modeling aided in the design of the water system and transmission main, which was complex due to the difficulties of providing treated water to three different cities with different pressure zones and flow requirements. The BCRUA WTP will have an ultimate built out of 105.8-mgd in 2025. She also completed the final design of the BCRUA booster pump station for three vertical turbine pumps.

Pump System Evaluation, City of Lubbock, Texas—Ms. McCullough evaluated the eleven pump stations for future capital improvements for the City of Lubbock. This evaluation included an inspection of pumps, motors, pipe, and associated storage tanks. A list of improvements was generated to add the City of Lubbock Capital Improvements Projects. As part of the project Ms. McCullough preformed pump tests on all of the pumps to study pump efficiency and perform an energy analysis.

Primary Effluent Pump Station Ph III, Las Vegas, Nevada—Clark County PEPS III is a 416 MGD permitted wastewater treatment plant serving the Las Vegas Nevada area. LAN was hired to design the Influent Lift Station for the WWTP. Ms. McCullough provided QA/QC on the pump hydraulic model. She verified quantities, system head curves, and static and friction losses in the model.

Strategic Study, Coastal Water Authority, Fort Bend County, Houston, Texas—The purpose of this study was to provide a plan for the future infrastructure requirements needed to meet the wholesale water needs of the Greater Houston Region. Ms. McCullough utilized GIS to determine water demand projections through 2060 in Fort Bend County. This study included a thorough analysis of the surface water required to convert the County's water supply to surface water from groundwater, due to groundwater subsidence.

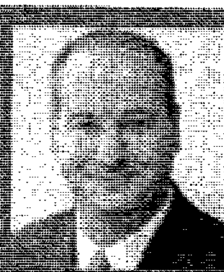
Project Team

Rollie A. McNutt, PE
Mechanical Engineer

Education
BS, Mechanical Engineering
Texas Tech University, [illegible]

Registration
Professional Engineer, Michigan, No. [illegible]

Years of Experience
19



Background
Mr. McNutt has 19 years of experience in the design of mechanical systems. He has designed a wide variety of systems including central utility plants, large air handling unit systems, smoke evacuation systems, industrial exhaust systems, and laboratory systems to National Institute of Health (NIH) guidelines. His areas of expertise include energy analysis, HVAC system optimization, building automation, and system commissioning. He has expertise in air conditioning, chilled water systems, thermodynamics, heat transfer and fluid mechanics.

Related Experience
Muddy Creek Regional Wastewater Treatment Plant (WWTP), North Texas Municipal Water District (NTMWD), Texas—The NTMWD contracted LAN to provide design, construction drawings, specifications, and construction phase services for the first phase expansion of the Muddy Creek Regional WWTP from its existing 5-mgd capacity to 10-mgd capacity. In addition to serving as the mechanical engineer during construction administration, Mr. McNutt designed HVAC systems for several buildings as part of this project. The overall expansion included modification of the on-site lift station, addition of a primary clarifier, two aeration basins, a secondary clarifier, two filters and ultraviolet disinfection modules. With the increase in energy costs, LAN evaluated options to reduce energy costs, particularly those associated with the aeration units and odor control system.

Primary Effluent Pump Station Ph III, Las Vegas, Nevada—LAN partnered with Whiting-Turner Construction for this design-build project for expansion of the PEPS from its current peak flow capacity of 120-mgd, to a peak capacity of 320-mgd. In addition to the expansion of the existing wet well and pumping capacity, the project involved the design and construction of a number of associated facilities including underground large diameter pipelines (72-inch and 96-inch), miscellaneous above-ground process piping, structural modifications to overhead canopy, electrical system design, odor control system design and large-diameter sanitary sewer pipe rehabilitation. The construction cost of the facility was approximately $29 million to be designed and constructed over an 18-month period. Mr. McNutt served as a technical resources and quality reviewer for the project.

Southwest Pump Station, City of Lubbock, Texas—LAN converted the City's existing hydraulic model from H2ONet to WaterCAD and incorporated growth projections. LAN prepared a preliminary report with recommendations and the subsequent construction documents. Mr. McNutt provided mechanical engineering evaluations of the existing cooling equipment (exhaust fans) for the pumps as well as the large compressors. Finally, LAN provided full construction phase services for the project.

Pump System Evaluation, City of Lubbock, Texas—Mr. McNutt was the mechanical engineer responsible for significant elements of the technical mechanical engineering systems design, documentation, calculations, code compliance, project detailing, specifications and mechanical engineering coordination. The project added a new 14-mgd pump station and included hydraulic modeling, site analysis, transmission line design, cost estimation, water conservation, and pump station design that included modifications to improve system maintainability and reliability. LAN also assisted with construction-phase (submittal review, inspection, and preparation of record drawings) and start-up services.

Hubbard Hall HVAC Systems Upgrade, Denton, Texas—As a mechanical engineer, Mr. McNutt was responsible for significant elements of mechanical engineering systems design, documentation, calculations, code compliance, project detailing, specifications and mechanical engineering coordination. TWU selected LAN to perform mechanical, electrical and infrastructure modifications for Hubbard Hall. The bulk of the construction required creative phasing to accommodate the numerous ongoing campus activities. All work was completed without major interruption to the building's complex schedule of activities.

Project Team

Osvaldo Garza, PE
Project Engineer

Education
BS, Civil Engineering
University of Illinois at Chicago, 2008

Registration
Professional Engineer, Illinois, No. [illegible]

Years of Experience
10

Background
Mr. Garza joined LAN in 2008 and has worked extensively on all aspects civil site and utility design. He has focused primarily on water distribution projects, while also gaining experience in roadway, storm sewer, and sanitary sewer design. His design experience has included developing final design drawings, technical specifications, construction cost estimates, bid documents, and providing construction phase services. Additionally, Mr. Garza has served as field engineer on a variety of projects including conducting internal inspections and evaluations of pipelines, utility vaults, and above ground utility structures.

Related Experience
Lake Pumping Station Improvements, Green Bay Water Utility, Green Bay, Wisconsin—Mr. Garza assisted with the preparation of plans and specifications. Preparation of plans included pump station site plan, 42-inch discharge header plan and profile design, as well as structural details and cross sections. Mr. Garza also performed thrust restraint calculations for the 42-inch discharge piping.

Tri State Village Water Association Water Distribution Improvements, DuPage County, Illinois—Mr. Garza assisted with the preparation of a complete construction package, including plans, specifications and estimate, for water main replacement within a residential neighborhood. Project consisted of 6,000 LF of 6-inch, 8-inch, and 10-inch water main installation.

Knollwood Wastewater Treatment Plant Air Header Replacement, DuPage County, Illinois—Mr. Garza assisted with the preparation of a complete construction package, including plans, specifications, and estimate for modifications to an existing air header and installation of a 30-inch air header and three blowers. As part of this effort, Mr. Garza reviewed record information and developed piping plans, structural details, as well as cross sections.

Surface Water Transmission Program (SWTP), City of Houston, Texas—Mr. Garza has served as Project Engineer on several large diameter water main projects ranging from 36 inches to 72 inches in diameter. His responsibilities included design of horizontal and vertical alignments, design of utility relocations, CAD drafting, development of technical specifications, preparation of bid documents, as well as coordination with private utility companies and public agencies. The complexity of these projects included design of thrust restraint systems, review of cathodic protection systems, traffic control plans, geotechnical reports, and environmental assessments to address specific design requirements. Some of the SWTP projects Mr. Garza worked on include:

Contract 73B-2: Approximately 8,500 LF of 42 inch water transmission main, 425 LF of 30-inch yard piping at SBPS, a new 30-inch metering station with 24-inch bypass, four 30-inch tank connections, and improvements at SBPS to the chlorinator, ammoniator, and SCADA system. In addition, the project included extensive pavement reconstruction along Tidewater, South Post Oak, West Orem, and Croquet.

Contract 70A-1: Approximately 5,600 LF of 72-inch water transmission main, interconnection to an existing 96-inch water transmission main, as well as storm sewer upgrades and relocations. The project also included removal and replacement of two lanes of reinforced concrete pavement along Fuqua St. from east of Beamer Rd. to Stover St.

Contract 70A-2: Approximately 6,700 LF of 72-inch water transmission main, 6,600 LF of 12-inch water main, storm sewer upgrades and relocations, relocation of 12-inch and 24-inch parallel force mains, and two lanes of reinforced concrete pavement replacement along Fuqua St. from Stover St. to Moers Rd. The project also included improvements to Southwest Pump Station consisting of roof replacement of existing Pump and Ammonia Buildings, installation of 30-inch, 36-inch, and 42-inch yard piping and tank connections, as well as a 42-inch metering station.

Project Team

Jennifer N. Savage, PE
Structural Engineer

Education:
BS, Civil Engineering
Texas Tech University, 2007

Registration:
Professional Engineer, Texas, No. 111616

Years of Experience:

Background
As a production enginer in the structural engineering department of LAN, Mrs. Savage designs and analyes components of contcrete and steel structures for a variety of projects including including buildings, water/wastewater treatment plants, port container yards, marine structures, pipeline aerial crossings, and miscellaneous structures.

Ms. Savage has designed numerous structures in the Gulf Coast Region to withstand hurricane force winds. Among these structures are the structural steel framed roof for a six story building in New Orleans, LA; a lift station elevated 20 feet above grade in Galveston, TX, and several elevated platforms to house hydraulic equipment for the Galveston-Bolivar Ferry in Galveston, TX and Bolivar, TX. She has provided preliminary and final engineering services as well as construction services for a wide variety of clients including, the US Army Corp of Engineers, Baylor University, Xavier University, Coastal Water Authority, City of Houston, Port of Houston Authority, and the City of College Station.

Related Experience
Primary Effluent Pump Station Ph III, Las Vegas, Nevada— Ms. Savage served as the structural designer for the portions of expansion of an existing pump station; a multi-chamber odor control tank and a CMU building. The multi-chamber odor control tank was 60 feet by 25 feet containing three main chambers with interior baffles and gates that would allow water to flow between the chambers. This design was especially challenging due to the high seismicity of this region. In addition to designing this tank for dead loads, live loads, and the static load of water in the tank. Ms. Savage calculated and designed the tank for the sloshing effect of the water in the chamber during a seismic event, using the design reference "Rectangular Concrete Tanks" by PSI to calculate the seismic force of the water.

Additionally, she designed portions of a load bearing rectangular CMU building that was approximately 50 feet by 15 feet; calculating the seismic force on the building in two orthogonal directions, and the relative stiffness of each of the walls to be used as shear walls. All CMU walls were designed to resist the seismic forces as well as the dead, live, and wind forces.

Water Treatment Plant Improvements, City of Robinson, Texas—Due to increased demand for potable water in this area the City was faced with a need to provide additional pumping and storage for the treatment plant and other miscellaneous items. The City authorized LAN to provide the design for the improvements that included the construction of a new 500,000 gallon clearwell, an additional 1000 GPM vertical turbine pump, relocation of two existing 2250 gpm pumps, piping and connection to existing piping, site work, electrical improvements for the additional vertical turbine pump, replacing spray bars on the Microfloc units, and check valve replacement at the raw water intake. Ms. Savage served as the structural designer for this project.

Sugarland Aerial Crossing at Ditch H and Oyster Creek— Ms. Savage designed two identical 150 foot, three-span aerial crossings to carry a 24-inch diameter waterline and a future 18-inch diameter force main across Ditch H and Oyster Creek. The superstructure consisted of TxDOT Pre-stressed Box Beams designed using the program PGSuper. Dead and live load to the superstructure were designed in PGSuper, and structure modeling was prepared using to analyze stresses imposed by the wind load and to calculate the reactions to be transmitted into the bent caps.

Regional Water Treatment Plant (WTP) Filter and River Crossing Improvements, Gatesville, Texas—Ms. Savage served as structural designer for the addition of two new filter trains, including a common piping gallery, pump pads and trenches consisting of cast-in-place concrete elements supported on thickened, slab-on-grade foundation elements. The addition of a new blower building, which consisted of a pre-engineered metal building founded on a slab-on-grade, and the addition of a new control building consisting of a pre-engineered metal building founded on an elevated, cast-in-place concrete slab was provided. The project was scheduled for completion within 200 days.

Project Team

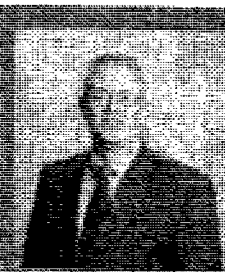
Jeffrey D. Alpers, PE
Project Manager

Education:
Masters of Civil Engineering, Water Resources Engineering
Michigan Technological University, [illegible]

Bachelor of Engineering, Civil Engineering
Michigan Technological University, [illegible]

Registration:
Professional Engineer, Michigan, No. [illegible]

Years of Experience:
15



Background
Mr. Alpers as a Project Engineer is responsible for the technical aspects of design, plan and specification preparation, and client correspondence on a variety of civil/ municipal projects working closely with the Project Manager. Mr. Alpers has been involved in sewer studies and design and also water main design. Mr. Alpers has experience in construction observation, inspection, and material testing. Mr. Alpers undergraduate studies were in environmental engineering while his graduate studies emphasized hydraulics and hydrology.

Related Experience
William R. Starr Camp and Conference Center Sanitary Sewer Rehabilitation Project—Project Engineer and Resident Project Representative. Performed preliminary investigations, design, preparation of construction documents, permit applications, construction administration duties, construction observation, and project close-out documentation.

Dimondale Estates Drain Improvements, Eaton County Drain Commission—Project Engineer. Performed initial field investigations, design, contract document preparation, construction administration dutie, and project close-out documentation.

I-94 Pelham Rd. to Wyoming Ave. Water and Sewer Improvements—Project Professional. Performed design and layout of water and sewer improvements and specification development.

Western Sub-Trunk Interceptor Parts A and B, Genesee County Drain Commission—Project Professional, performed preliminary design calculations and layouts, utility coordination, construction document preparation.

Tecumseh River Service Area Sanitary Sewer Rehabilitation (Trenchless), City of Lansing, Michigan—Project Professional, Performed construction administration duties, supervision of field personnel, and construction.

Tecumseh River Service Area Open Cut Sewer Rehabilitation, City of Lansing, Michigan—Project Professional and Resident Project Representative. Performed construction administration duties, supervision of field staff and construction observation.

Wastewater System Improvements, Village of Ashley, Michigan—Project Professional. Oversight performing preparation of environmental report and USDA-Rural Development Funding application.

2013 South Sewer Separation Project, City of Lansing, Michigan—Prepared preliminary design, Basis of Design report.

Northeast Interceptor, City of Lansing, Michigan—Prepared final design, performed Project Performance Certification (PPC) investigations and developed draft PPC report.

Moores Park Trunk Sewer, City of Lansing, Michigan—Performed preliminary design investigations and layout, conducted Project Performance Certification (PPC) investigations, and developed final PPC report.

022 West and Area I/J Sewer Separation Project, City of Lansing, Michigan—Performed Project Performance Certification (PPC) field investigations and developed draft PPC report.

Tecumseh River Road Pump Station Inflow/Infiltration Study, City of Lansing, Michigan—Project Engineer, performing field investigations, developed preliminary recommendations, prepared report.

Project Team

Steven T. Luoma, PE
Senior Project Manager

Education:
Bachelor of Engineering, Civil Engineering
University of Michigan, [illegible]

Registration:
Professional Engineer, Michigan, No. [illegible]

Years of Experience:
16

Background
Mr. Luoma has 16 years of experience on a wide variety of civil engineering projects. As a Project Engineer/Manager he is responsible for the technical aspects of design, plan and specification preparation, project management and client management for a variety of civil/governmental/municipal projects. Mr. Luoma has been involved in highway improvement design, airfield pavement design, storm sewer, sanitary sewer, water treatment, wastewater treatment and site design. Mr. Luoma has extensive experience in preparation of permit applications, construction engineering and project management.

Related Experience

Main Street Pump Station, City of East Tawas, Michigan— Project Manager/Design Engineer for evaluation of sanitary sewer pump station in downtown East Tawas. A new pump station was required due to high maintenance of existing pumps and poor configuration of pump station. Designed a new pump station adjacent to the old pump station that allowed for continued service throughout the construction period. Prepared design documents and provided oversight of bidding and construction of the new pump station.

General Motors Hot Weather Facility, Yuma, Arizona— Project Engineer for this 2,500 acre test track facility and associated building campus area for hot weather vehicle testing. Responsible for preparing USACE permit, Arizona Department of Environmental Quality permits for water system, sanitary sewer system, and aquifer protection from wastewater discharge. Designed potable water distribution network from well to buildings, fire protection network, water treatment for potable water system, potable water storage (50,000 gallon above ground tank), fire protection storage (250,000 gallon above ground tank), and booster pump station for water system. Water treatment consisted of a green sand filter system for removal of arsenic from the groundwater source and design of evaporation ponds for backwash water from water treatment. Also responsible for preparation of design plans and specifications for wastewater facilities for the building campus, treatment of discharge from cooling tower, and treatment of discharge from car wash (package unit).

US Army Corps of Engineers, Soo Locks Multi-Building Rehabilitation Soo Locks, Sault Ste. Marie, Michigan— Assisted in the design, plan preparation and specification development for the rehabilitation of five historically significant buildings on the Soo Locks Complex. Repairs included rehabilitating and restoring function to historical building features (windows, doors, masonry). Project required approval from State Historic Preservation Office. Also prepared detailed cost estimates for each building's planned renovations using the Corps of Engineers MII cost estimating software.

Tecumseh River Pump Station SSO Area, City of Lansing-Public Service Dept., Lansing, Michigan—Staff Engineer reviewed and implemented I & I study recommendations for sanitary sewer system rehabilitation and repair. Prepared plans, details and specifications for selected trenchless and open-cut sewer repairs implemented. The project involves the rehabilitation of the sewer system to eliminate potential infiltration/inflow sources and minimize the frequency of sanitary sewer overflows and related basement backups. It also requires an evaluation of the system performance at the end of the construction to determine the effectiveness of the rehabilitation methods implemented. Construction phase involved the daily inspection and testing for sanitary sewer upgrades, storm drainage and road reconstruction including aggregate base courses, concrete curb, and HMA construction.

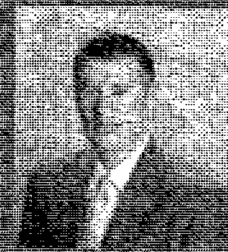
US Army Corps of Engineers, Soo Locks Master Plan, Sault Ste. Marie, Michigan—Design Engineer for future Soo Locks Canal Park development activities, specifically redesign and rehabilitation of parking lots, pier lighting upgrades, park lighting modernization, and landscape improvements. Principally in charge of preparing project plans and cost estimates for the four segmented project.

Project Team

ERIC D. BROWN
Senior Designer

Education:
BS, Building & Construction Management
Michigan State University, 1992

Years of Experience
20



Background
Mr. Brown has 20 years of experience on a wide variety of civil engineering and architectural projects. As a Engineering Tech, he is responsible for the technical aspects of design, drafting and construction document preparation on a variety of civil/governmental/municipal projects working closely with the Project Manager. He is experienced in the preparation of drawings from surveyed field data showing topographical features, surface model creation, plan and profile generation depicting road and utility design, construction detail drawings and everything else required for project construction documents. Mr. Brown has been involved in subdivision plat, condominium docs, municipal utility, site plan, architectural, road design, streetscape and many other design projects. He has extensive knowledge and experience with AutoCAD 2010, AutoCAD Civ3D 2010, Microstation and Microsoft office products.

Related Experience
Highland Park Water System Improvements, Highland Park, Michigan—Prepared construction Documents for improvements to water distribution system and water treatment system in the city of Highland Park funded by Drinking Water Revolving Funds. Established base plans from aerial photography and survey to be used for design in project set.

Western Sub Interceptor, Genesee Co. Drain, Swartz Creek, Michigan—Developed design drawings for the construction of approximately 8.5 miles of 40" interceptor sewer for four municipalities throughout the county. Developed topographical feature drawings from survey information and collected field data using Landdesk 2004. Created plan and profile drawings depicting sanitary sewer layout design. Drafted complete set of plans for construction documents and assisted the county in establishing CAD drafting standards.

Watermain Project, Board of Water and Light, Bath, Michigan—Established existing topographical feature drawing from survey information. Developed plan and profile drawings depicting water main layout design. Drafted complete set of plans for construction documents.

Waverly Road Watermain Upgrade Project, Lansing, Michigan—Established digital terrain models using caice software from points collected from survey crew. Established full construction documents using AutoCAD including plan and profile drawing depicting project design. This was a waterman system upgrade project.

Glycol Collection System, Capital Region Airport Authority, Lansing, Michigan—Developed existing topographical drawing from surveyed and existing aerial map information. Developed construction plans including plan and profile drawings depicting existing utilities and design utilities.

Tecumseh River Pump Station SSO Area, City of Lansing-Public Service Dept., Lansing, Michigan—Plan preparation for sanitary sewer system rehabilitation and repair. Prepared construction documents including base plans, plan and profile plans for trenchless and open-cut sanitary sewer repair. The project involves the rehabilitation of the sewer system to eliminate potential infiltration/inflow (I/I) sources and minimize the frequency of sanitary sewer overflows (SSOs) and related basement backups.

Bath Township Sewer Master Plan, Southern Clinton County Municipal Utilities Authority, Michigan—Developed an AutoCAD master plan map of Bath Township sewer system from existing as-built information plans.

City of Lansing CMI Riverfront Project, Lansing, Michigan—Established construction documents for the design of the river trail and other project amenities between Michigan Ave. and Shiawassee Street along both sides of the Grand River in downtown Lansing. The project includes design and construction engineering for approximately 2,500 LFT of 14' to 20' wide river trail along with 4' retaining wall and elevated truss bridge section including outlook areas, landscaping and wetland areas.

Project Team

Michael V. Liga, Ph.D., PE

Education
Ph.D., Environmental Engineering & Science
Rice University, 2012

MS, Civil and Environmental Engineering
Rice University, 2009

BS, Agric. and Biosystems Engineering
University of Arizona, 2004

Years of Experience
3

Related Experience

Rice University Department of Civil and Environmental Engineering, Houston, Texas

- Development of advanced oxidation processes using engineered nanomaterials for drinking water treatment with focus on human adenovirus inactivation
- Development of strategies to improve nanomaterial efficiency and elucidation of improvement mechanisms
- Reaction kinetic modeling
- Investigation of virus photocatalytic inactivation mechanisms using biochemical assays to probe protein and genetic damage (SDS-PAGE, PCR methods)
- Development of processes and protocols for evaluating the long term efficacy of antimicrobial surfaces. Troubleshooting and optimization of existing short-term assays for evaluating antimicrobial activity
- Development of nano-functionalized fabrics for trapping viruses in aqueous media
- Collaboration with other research groups / departments
- Operate and maintain biosafety level 2 lab equipment and protocols
- Authorship of technical publications and presentations
- Management, training, and supervision of undergraduate research assistants
- Ordering and inventory of labortory supplies

Natural Resources Conservation Service, Salinas, California

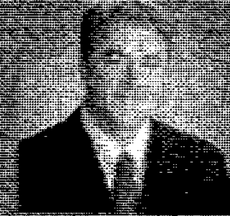
- Planning, design, drafting, and construction inspection of water treatment and reuse systems, pressure and drainage pipelines, open channels, stormwater management systems, wastewater management systems
- Hydrological analysis
- Topographical surveying, land surface modeling, and cartography
- Construction site survey
- Resource management and planning for agricultural operations
- Consultation with regulatory agencies, property owners / operators and contractors
- Technical reporting and design presentation
- Operate in term environment

USDA Natural Resources Conservation Services, Tucson, Arizona

- Surveying, design, and inspection of pipelines, irrigation systems, and animal waste management systems
- Engineering calculation and report writing

Project Team

DANIEL W. BARTLETT, PE, CFM
Senior Engineer



Education:
BS, Civil Engineering
Michigan State University, 2002

Registration:
Professional Engineer, Michigan, No. [illegible]

Certification:
Certified Floodplain Manager (CFM) [illegible]

Years of Experience:
[illegible]

Background
Dan joined ROWE in 1999 as a student survey field technician. He joined the firm as a full-time graduate engineer in 2002, was promoted to assistant project engineer in 2006, and to project engineer in 2008. In 2012, Dan was named associate (owner) and promoted to senior engineer. At ROWE, Dan is in charge of water modeling efforts, hydrology, and hydraulic studies for storm water, water, and sewer systems.

Related Experience
Water Reliability Study, City of Lapeer, Michigan—Prepared water model and reliability study update using WaterCAD. Incorporated recent and proposed improvements as well as changes in supply and demand. Included analysis comparing options between continuing to receive water from an existing regional authority, a new authority, and converting backup wells to production wells (ongoing).

Waste Water Treatment Plant Improvements, City of Lapeer, Michigan—Project engineer for design and construction of improvements to the wastewater treatment plant, which consist of the following: new bypass pumping station, replace existing Parshall flume, replace/upgrade raw water screw pumps, new grit removal system, replace various meters and pumps, refurbish final settling tanks, replace rotating weir structures in the oxidation ditches, refurbish sand filters, construct new phosphorous selector tank, replace influent gravity sewer pipe with larger pipe, replace existing water main, upgrade main electrical controls and equipment and install new SCADA system (2010).

Booster Station Design and Water Storage Analysis, Birch Run Township, Michigan—Utilized WaterCAD model of the township's system to design a new booster pump station for water supply. Developed options for providing water storage and recommended a location and height of an elevated storage tank to serve the township (2009).

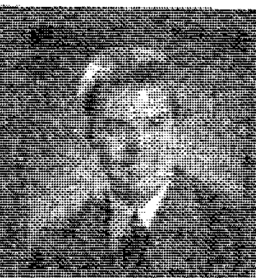
Sanitary Sewer System, Green Oak Charter Township, Michigan—(Awarded 2005 Public Works Project of Year, Environmental Category, $2-$10 M Category, American Public Works Association): Design engineering for sanitary sewer system. Project included four large pump stations, several thousand feet of gravity and low pressure sewer and force mains ($6M construction; 2005).

Silver Lake Sanitary Sewer Study: Assisted with preparation of feasibility study report. Included evaluation of several different sewage collection systems and routes to serve approximately 170 lake parcels. Presented alternatives for gravity collection and grinder pump/low-pressure sewer systems. Report also included projected wastewater flows and cost estimates for each alternative sewage collection system (2004).

Water Reliability Study, Oxford Charter Township, Michigan—Revised previous water master plan based on current development and future developments. Analyzed current water usage based on development type (i.e., with or without irrigation systems) and projected future water consumption. Analyzed several distribution system improvements using WaterCAD software. The township's system features several supply wells with SCADA controls, storage facilities, and multiple pressure zones. Model utilized extended period simulations to analyze existing system performance and expected results from recommended improvements. Prepared comprehensive report outlining findings and recommended improvements. Held meetings with representatives from the Oakland County Water Resources Commissioner's office to illustrate the existing system performance and presented several different options for improving performance (2006).

Project Team

Douglas A. Scott, PE, LEED®AP BD+C
Project Manager



Education:
BS, Civil Engineering
Michigan State University, [illegible]

Registration:
Professional Engineer, Michigan, No. 6201[illegible]

Certification:
Leadership in Energy and Environmental Design (LEED®AP), 2008
LEED®AP Building Design and Construction, 2011
[illegible] Board Certified, 2007 [illegible] 12412

Years of Experience:
21

Background
Doug has 21 years of professional experience, focusing on project design and development for a variety of municipal and private clients. He joined ROWE as an assistant project engineer in 1995, was promoted to project engineer in 1997, was named an associate (owner) in 1998, and was promoted to project manager in 2001.

Design emphasis has been in water and wastewater, including design of well houses, water storage, water and wastewater pump stations, treatment plants, and municipal water and sewer projects. He has also served as project manager/engineer for numerous site development and redevelopment projects for institutional and commercial facilities. Doug has been involved in the design of many school, parks, and hospital site plans throughout Michigan. He has also managed a number of demolition projects ranging in size from single-family structures to large multi-story buildings.

Related Experience
Wastewater Treatment Plant Improvements, City of Lapeer, Michigan—Project engineer for design and construction of improvements to the wastewater treatment plant, which consist of the following: new bypass pumping station, replace existing Parshall flume, replace/upgrade raw water screw pumps, new grit removal system, replace various meters and pumps, refurbish final settling tanks, replace rotating weir structures in the oxidation ditches, refurbish sand filters, construct new phosphorous selector tank, replace influent gravity sewer pipe with larger pipe, replace existing water main, upgrade main electrical controls and equipment and install new SCADA system (2010).

Water Treatment Plant, City of Linden, Michigan—Project manager preparing construction documents for a new 1,350-gpm water treatment plant. Project involved selection of filtration equipment and complete design of treatment system including coordination of architectural, electrical and mechanical trades. Project included the design of a SCADA system to operate the city water system. Obtained an NPDES discharge permit for the backwash water. Construction administration and coordination of construction observation were also included (2005-09).

Back-Up Well System, City of Imlay City—The city receives water from the Detroit water system, but the MDEQ requires that the city have a back-up water source. The project involved expansion of an existing Type I water system, including a complete well house, new well, and connection to the public system. Additional amenities included variable frequency drives, a standby generator, and a control system to maintain constant pressure in the distribution system, in the event the elevated tank was out of service. Coordinated with the MDEQ through the permitting process (2007 design; 2008 construction).

2005 Water System Improvements, Village of Holly, Michigan—Project engineer for planning, design, and construction of major improvements to the water system (designed in 2005 and 2006; construction began in spring 2006 and was complete in summer 2007).

- New 1,000 gpm production well
- 500,000-gallon elevated storage tank
- Complete renovation and expansion of the water treatment plant, including the addition of three 10-foot-diameter filter vessels with automated backwash system, detention tank with discharge pump system, new service pumps, clearwell rehabilitation, and new electrical system, including standby generator with automatic transfer switch.
- Implementation of a new SCADA system for the water plant, including creation of a new high-pressure district.

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Project Team

Jonathan H. Rick, PS, CFedS
Project Manager

Education
BS, Surveying
Michigan Technological University, 2004

Registration
Professional Surveyor, Michigan, No. 55562
Certified Federal Surveyor (CFedS), No. 1255

Years of Experience
[illegible]

Background
Jonathan has been employed with ROWE since 2004, and has accumulated experience in the areas of topographic, ALTA, and cadastral PLSS surveys and Global Positioning System (GPS) surveys and control networks. He is responsible for overseeing the completion of survey projects in ROWE's corporate office.

Related Experience
Bay Area Water Treatment Plant, CDM Smith, Inc., Detroit, Michigan—Project surveyor for boundary, right-of-way, and topographic survey for the design of new 23 mgd water treatment plant and 20,000 lineal feet of 30-inch raw water transmission mains in Bay County, MI. Survey work was completed on an expedited schedule using multiple survey crews because of short design schedule. Base mapping and drawings were prepared for plant site and transmission main routes for use by designers (2013).

DWRF & SRF Project Plan, City of Flint, Michigan—Project surveyor for the development of project plan that met MDEQ requirements for potential funding (2009).

Federal Energy Regulatory Commission (FERC) Licensing Update Submittal, City of St. Louis, Missouri—Project surveyor for the licensing renewal submittal (recertification) to the FERC for the St. Louis Hydroelectric Dam (2011).

2010 Sanitary Sewer Replacement, City of Alma, Michigan—Project surveyor for the replacement of 24-inch sanitary sewer along the Pine River (2011).

2010 Summer Civil Design and Construction Administration, Central Michigan University, Mt. Pleasant, Michigan—Design, construction observation, and contract administration for three construction projects on campus: parking lot projects, IM field improvements, and water main directional drill (2010).

Gratiot Wind Farm, Aristeo, Gratiot County, Michigan—Project surveyor responsible for scheduling, calculations, data processing and QA/QC. The wind farm includes 132 proposed wind turbine sites in four townships. Project included topographic survey, civil design and construction staking of 56 intersection widenings and 10 rail road crossings along the haul routes (2011).

West Oakland Pipeline (Clarkston, MI) (Awarded 2013 Surveying Excellence Honorable Conceptor Award: American Council of Engineering Companies-Michigan), Consumers Energy, Clarkston, Michigan—Field project surveyor for six miles of gas pipeline. This very fast-paced project involved staking centerline, right-of-way determination, and temporary construction use areas for clearing and again for installation of a 36" pipeline. Project included approximately 2/3 mile horizontal drill and 5.33 miles of open cut ditch, as-built pipeline, monitor railroad tracks and overhead power tower, and sight topo survey. Assisted restoration crews with final site cleanup. Specific duties included attending daily project contractor meetings and biweekly project management meetings, scheduling field crews, processing and checking field data, assisting field crews when necessary, providing contractor assistance in ground cover checks, and assembling data for final project submittal (2009).

Appendix C

Project Resumes

Water Treatment

Lockwood, Andrews & Newnam, Inc. (LAN)

LAN is a national engineering firm offering planning, engineering, and program management services. **LAN is consistently rated in the top 100 A/E firms by Engineering News-Record magazine.** As a subsidiary of Leo A Daly, one of the largest planning, architecture, engineering, and interior design firms in the United States, LAN has access to the expertise of more than 1,100 professionals in 25 offices in 21 cities worldwide.

Water System Engineering.
Water system engineering is the largest component of LAN's infrastructure practice and constitutes almost half of LAN's annual work. We have in-house capabilities in all aspects of water supply, transmission, distribution, and treatment.

> LAN is a client-oriented firm, believing that the principal factor behind our success and growth has been our dedication to long-term client satisfaction through the production of high-quality, timely work.

Our approach to water system design and construction is to fully integrate all engineering disciplines, including civil, environmental, hydrologic/hydraulic, mechanical, electrical, instrumentation and controls, and structural for every project. Relying on this approach, we are able to take a program or project from feasibility studies and preliminary planning to construction and operation while providing program, project and construction management.

Water Treatment Expertise.
LAN has a reputation for designing facilities that are innovative, durable, convenient to operate and maintain, and are cost-effective throughout their life cycle. **Our expertise includes conventional and advanced treatment technologies.**

LAN has provided services for more than 30 water treatment projects throughout the US, ranging from 2- to 120-mgd. LAN has the capability and capacity to successfully complete every aspect of a water treatment project, from feasibility studies, all the way through facility start-up. Our in-house engineering design services include: process, civil, structural, hydraulic, chemical, mechanical/HVAC, and electrical.

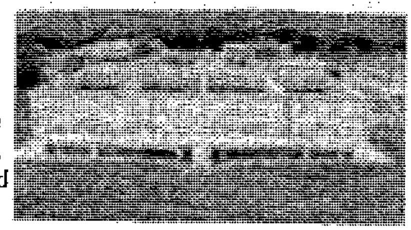
Our project implementation services include: project management, progress scheduling, contract administration, on-site technical observation, start-up support, operational assistance, and operator training.

Regional WTP Filter & River Crossing Improvements
Gatesville Regional Water Supply System, Gatesville, Texas

LAN was authorized by the City of Gatesville to provide the design, bidding, construction administration, and construction observation services for a project to accomplish improvements and additions to the facility's existing filters at the regional water treatment plant. The existing filters were rated for 12.0-mgd and had been in service for more than 20 years without any significant improvements.

In particular, the design effort included the replacement of the dual media in each of the four existing filters along with the removal and replacement of the existing filter under drains, and the addition of two new dual media filters for a total filtering capacity of 16.0-mgd. New filter controls were also installed for both the existing and proposed filters. In addition, the existing surface wash system for the existing filters was removed and air scour added to the back wash cycle.

Moreover, the City of Gatesville requested that filter to waste capability be added to the existing filters, as well as in conjunction with the design of the new filters. Upon review of the existing pipe gallery, LAN discovered that there was no available space to install the piping required to facilitate the filter to waste provision, therefore, LAN proposed to utilize the existing backwash line, along with the backwash waste line, as a filter to waste, with a few piping modifications and the addition of one valve.



Project Information

Original Construction Cost	$2,132,000
Final Construction Cost	$2,382,037
Change Orders	$250,036
Client Contact	Berry Mansell 254.986.8281

Red Bluff Water Treatment Plant Upgrades
Coastal Water Authority, Texas

LAN evaluated the existing water treatment plant to determine maximum capacity of each process unit and to establish a method to debottleneck the entire plant. It was determined that the plant flow could be increased utilizing the existing clarifier as long as additional filtration was provided. In addition process modifications were recommended. There was high variability of the raw water flow rate because the single loop PID controller varied the position of the raw water valve, based only on the level in the clearwell. Because of highly variable customer demand and a relatively small clearwell, the raw water flow rate varied over a wide range and short period of time, negatively impacting the stability of the lime softening process.

The PLC-based system allowed for the programming of a unique function that adjusted the raw water flow rate on a backward-looking rolling average flow, with duration and update time operator adjustable. This allowed for better utilization of the clearwell and dampens changes in raw water flow rate. The plants old relay-based master control panel (MCP) was replaced with a new PLC-based SCADA system which included a data historian.

LAN developed detailed drawings and specifications, and provided bid and construction phase services for implementing these upgrades.

Project Information

Original Construction Cost	$2,478,729
Final Construction Cost	$2,451,463
Change Orders	($27,266)
Client Contact	Donald Ripley 713.658.1915

Water Treatment

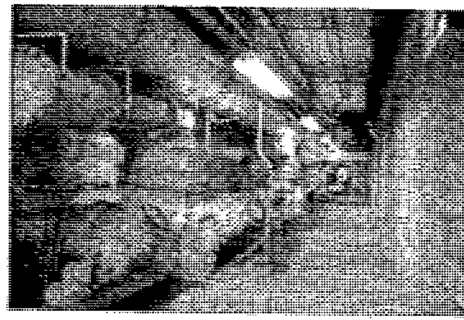
Davis WTP Filter Valve Replacement
City of Austin, Texas

LAN provided preliminary engineering, final design, and construction- and warranty-phase services for filter process improvements and valve replacements. LAN evaluated the filter infrastructure including piping, valves, actuators, pipe supports, surge/air release devices, wall penetrations, back-wash pumping and piping under drain systems, and recommended modifications to improve system maintainability and reliability. LAN provided the necessary electrical upgrades to the power, instrumentation and controls systems.

LAN completed the Preliminary Engineering Report (PER) that evaluated the existing filtering system and recommended modifications to enhance the treatment process. The PER presented the improvement options with associated estimated life-cycle and the construction costs of each option. The preliminary report required close coordination with the City staff so that timing of the proposed improvements could be properly dictated to the contractor. In addition, LAN worked closely with the Staff to make certain the proposed improvements and equipment was acceptable from an operation and maintenance standpoint.

LAN then prepared construction plans and specifications for the project, including the replacement of the old back-up backwash pump. Because of the tight nature of the working area, the construction documents had to be extremely thorough so that the bidding contractors properly understood the constraints.

As a result of the thorough design documents, the low bid came in at 20% below the Engineer's estimate.



Services Provided: LAN then prepared construction plans and specifications for the project, including the replacement of the old back-up backwash pump. Because of the tight nature of the working area, the construction documents had to be extremely thorough so that the bidding contractors properly understood the constraints. As a result of the thorough design documents, the low bid came in at 20% below the Engineer's estimate.

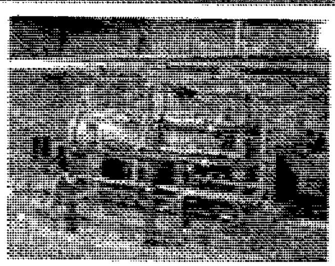
Project Information

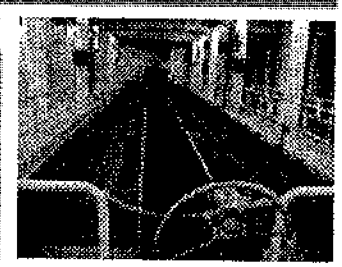
Original Construction Cost	$4,875,000
Final Construction Cost	$5,073,391
Change Orders	$198,391
Client Contact	James King, PE 512.972.7194

Water Treatment Plant Study
Genesee County Drain Commissioner, Flint, Michigan

LAN was retained for the preparation of a preliminary design report for additional improvements to the Flint water treatment plant as part of the Lake Huron initiative. This preliminary engineering report outlined the additional requirements and improvements for water treatment plant continuous operation as opposed to the current standby status. Recommended improvements included the addition of lime sludge treatment and handling facilities, replacement of the low and high lift pumps and motors, standby power generators, UV disinfection, electrical and SCADA improvements, and additional chemical storage.

Due to decrease in population and subsequent reduction of water demands, the proposed improvements were based on an average day demand of 14-mgd, down from 20-mgd, and a maximum day demand of 28-mgd, down from 36-mgd. Each of the major project elements a described in the following sections.





Project Information

Original Construction Cost	$38,000
Final Construction Cost	$38,000
Change Orders	$0
Client Contact	Dave Jansen 810.732.7870

Bay County Water Treatment Plant
Saginaw-Midland Municipal Water Supply Corp. (SMMWSC), Michigan

The Saginaw-Midland Municipal Water Supply Corporation retained LAN to prepare a preliminary study for the feasibility of locating a 22-mgd surface water treatment plant (WTP) in the Bay Area to provide finished water to four potential municipal customers. The study included preliminary design of the WTP and associated water system facilities, evaluation of multiple WTP site options, and development of a detailed cost analysis.

Preliminary design of the WTP included:
- Verification of the design flow rate
- Development and evaluation of emergency water supply options
- Preliminary treatment plant design based on membrane technology
- WTP building layout and sizing
- Finished water storage
- High service pumping
- Routing of transmission mains
- Low service pumping and screening
- Membrane unit sizing, layout, and piping connections
- Chemical feed systems
- Clean-in-place (CIP) equipment, tanks, and chemical waste neutralization
- Backwash waste treatment and disposal
- CT analysis
- Disinfection options including chlorine feed and ultraviolet light

LAN evaluated seven potential WTP site options in terms of environmental and cultural factors, existing utilities and infrastructure, and technical considerations. In total, 24 categories were developed to analyze and score each site including items such as wetlands, site drainage, floodplains, soils, potential of site contamination, gas and electric service, sanitary service, site security, start-up of the WTP, operability, future growth, and integration with the existing water system. Various emergency water supply options were developed for each site including on-site raw water storage, off-site raw water storage, and/or utilization of a secondary intake. The evaluation categories were weighted in terms of importance and each site was assigned a non-monetary score. The non-monetary scores were then combined with the cost rankings to provide overall quantifiable rankings for all sites.

Project Information

Original Construction Cost	$75,000
Final Construction Cost	$75,000
Change Orders	$0
Client Contact	Mike Quinnell 989.684.2220

[illegible]

Saginaw Midland Municipal Water Supply Corporation Water Treatment Plant

Saginaw Midland Municipal Water Supply Corporation (SMMWSC) retained LAN to prepare a preliminary study for the feasibility of locating a 22-MGD surface water treatment plant (WTP) in the Bay Area to provide finished water to four potential municipal customers. The study included preliminary design of the WTP and associated water system facilities, evaluation of multiple WTP site options, and development of a detailed cost analysis.

<u>Preliminary Design of WTP and Associated Water System Facilities</u>
Preliminary design of the WTP included verification of the design flow rate, development and evaluation of emergency water supply options, preliminary treatment plant design based on membrane technology, WTP building layout and sizing, finished water storage, high service pumping, and routing of transmission mains. In order to verify the design flow rate, LAN collected current and projected water supply minimum, average, and maximum daily demand and fire flow information. Potential connection points to the existing distribution system were analyzed and the minimum and maximum pressures at each point were determined. Preliminary design of the WTP included low service pumping and screening; membrane unit sizing, layout, and piping connections; chemical feed systems; clean-in-place (CIP) equipment, tanks, and chemical waste neutralization; backwash waste treatment and disposal; Ct analysis; and disinfection options including chlorine feed and ultraviolet light. Preliminary design was developed in accordance with state regulations and input was obtained from MDNRE review staff. The WTP building was sized to accommodate treatment equipment, pumps, chemical storage and feed systems, electrical equipment, staff workspace and offices, mechanical equipment, maintenance rooms, laboratory and employee facilities.

<u>Preliminary Evaluation of WTP Site Options</u>
LAN evaluated seven potential WTP site options in terms of environmental and cultural factors, existing utilities and infrastructure, and technical considerations. In total, 24 categories were developed to analyze and score each site including items such as wetlands, site drainage, floodplains, soils, potential of site contamination, gas and electric service, sanitary service, site security, start-up of the WTP, operability, future growth, and integration with the existing water system. Various emergency water supply options were developed for each site including on-site raw water storage, off-site raw water storage and/or utilization of a secondary intake. The evaluation categories were weighted in terms of importance and each site was assigned a non-monetary score. The non-monetary scores were then combined with the cost rankings to provide overall quantifiable rankings for all sites.

<u>Detailed Cost Analysis</u>
Cost estimates developed for each site included property acquisition, building construction, HVAC, building electrical, treatment equipment, pumping equipment, storage facilities, SCADA and controls, transmission mains, site development, access drives and parking, utility services, and improvements necessary to the existing water system. In addition to capital costs, operation and maintenance costs were evaluated for each site. Items such as existing staff time, required new staff time, chemicals, membrane maintenance costs, utility costs, communications, insurance, lab operations, training, and general facilities maintenance were factored into O&M costs. Present worth values were then calculated in a detailed cost analysis. As part of the report, user rates were estimated based on the project cost and expected financing. A rate structure was assumed with a fixed portion to cover debt service and variable cost based on volume of water used by the customer.

<u>Untreated Water Supply Option</u>
As part of the report LAN also evaluated a wholesale raw water customer option where the customer would be responsible for treatment. Connection to the existing raw water supply pipeline, routing of the new transmission main(s), metering, and secondary supply options were developed along with the associated costs.

[illegible]

City of Lubbock WTP Assessment and Energy Audit

Lockwood, Andrews & Newnam, Inc. (LAN), in conjunction with Alan Plummer and Associates, completed a plant assessment and energy audit of the City's 80-mgd water treatment plant. The study was completed in early 2008, and LAN has begun design on Package 1 of 4 packages. Package 1 includes improvements to the flocculation, sedimentation and plant electrical systems. Package 2 will include backwash handling and disinfection improvements. Package 3 will include rapid mix and chemical system improvements. Package 4 will include terminal storage and administration building improvements.

Improvements selected by the City for implementation by LAN in the four packages include:

- Replace plant distribution switchgear with modifications to electrical service.
- Replace control building switchboard and distribution panels.
- Replace chemical building motor control center.
- Provide miscellaneous electrical, instrumentation, control, and SCADA improvements.
- Replace miscellaneous lighting systems with energy-efficient systems.
- Provide miscellaneous repairs to better seal building envelopes.
- Provide HVAC repairs and replacements with energy-efficient systems.

[illegible]

Bell County WCID Water and Wastewater Master Plan

LAN was authorized by Bell County WCID No. 1 to complete a water and wastewater master plan that would represent an improvement and future development plan for the District, as well as its existing and future customers. In particular, LAN was responsible for baseline information collection, population and demand projection determination, and the wastewater master planning portion of the project. Specifically, the baseline data and information was used to develop population projections for the District over a 50-year planning horizon (2010 to 2060). Per capita water usage and population projections were determined based on planning information received from the District's customers, as well as available Texas Water Development Board (TWDB) data. The per capita usage information was subsequently applied to anticipated population estimates for each customer entity over the period of concern. This information was ultimately used to calculate the water demand projections that were utilized as the basis for the water master planning effort.

In terms of the wastewater-related portion of the master plan, LAN initiated its assessment by establishing the existing average and peak wastewater flows of each customer entity using available recorded daily plant flow data and monthly billing data provided by the District. Next, a dry weather period was defined using rainfall records obtained from the National Weather Service. By definition, recorded wastewater flows during this timeframe were assumed to be representative of the baseflow condition for each treatment plant, as any additional flows from Infiltration and Inflow (I&I) sources would be eliminated as a contributing factor. The dry weather base flow data was then used in conjunction with the available baseline population data to calculate the per capita wastewater flow for each customer entity.

The dilapidated condition of the wastewater collection system infrastructure owned and maintained by the customer entities had resulted in significant I&I contributions at the District's treatment plants; therefore, LAN also completed an analysis to quantify the respective I&I flows being received at each wastewater facility. This was accomplished through a multi-step process, which effectively involved establishing a dry weather base flow over four consecutive 12-month wet weather periods. Using the per capita wastewater flow calculated for each member entity, and subsequently, subtracting that from the District-recorded plant flows for the same periods, an average I&I contribution percentage was determined. To conclude its existing conditions evaluation, LAN also identified and prioritized a list of required improvements at each of the District's wastewater treatment facilities.

The remainder of the wastewater master planning effort focused on an analysis of future conditions. Specifically, the projected wastewater flow contributions anticipated for each plant through the year 2060

were determined by multiplying the projected population for each year within the planning horizon by the established per capita flow rate, in order to quantify the base flow rate for each year. The base flow was then multiplied by the average I&I percentage for the facility, and the I&I flow and base flow subsequently summed to determine to total projected wastewater flow for each facility in a given year. From this information, the 75- and 90% capacity thresholds, per the Texas Commission on Environmental Quality (TCEQ) Chapter 305 regulations, were identified for each plant. A similar process was repeated as a means of evaluating the District's ability to serve additional customer entities in the future, as well as the impact of such a service area increase on the need for future plant expansions.

Finally, LAN prepared detailed probable cost estimates for the recommended wastewater capital improvements. Specifically, the estimates developed summarized the projected capital costs anticipated to be incurred by the District in association with the improvement of the identified existing treatment plant deficiencies, required future expansions, and the recurring end of equipment life expenditures at each facility. The anticipated costs were then allocated and prioritized over multiple five-year CIP cycles for the duration of the planning horizon with the intent of facilitating and guiding the District's future budgeting and project allocation efforts.

[illegible]

City of Beeville

The City of Beeville has continuously violated Haloacetic Acid (HAA) parameter of the Disinfection By-Products regulation of the Enhanced Surface Water Treatment Rule (ESWTR). That regulation sets a maximum limit of .06 mg/l on the concentration of HAA in drinking water. The Texas Commission on Environmental Quality (TCEQ) has directed the City to (1) cease these violations and (2) publicly notify their customers of the violations.

As part of their corrective action the City directed their engineer, Urban Engineers, to identify the cause of the high HAA level violations and recommend corrective action. Urban, recognizing LAN's expertise in water treatment matters, requested LAN assist them in identifying the cause of the high HAA levels and corrective action. The City produces drinking water at their Swinney Switch Water Treatment Plant (WTP). This plant is a surface water treatment plant located on the City's far east side. Water from this WTP is pumped to several pump stations located around the City for final distribution to local customers. Each pump station consists of at least one ground storage reservoir (GST) and a booster pump facility. Treated surface water is disinfected at the WTP using chloramines.

LAN's investigation noted the City only disinfects at the WTP. There were no supplemental disinfection facilities at the City's two pump stations. Since the chloramine disinfection concentration degrades with time, the City operators were compensating for that degradation by increasing the chloramine dosage level at the WTP. To maintain an acceptable minimum chloramine concentration at the farthest point in the water distribution system the WTP plant operators were increasing the chloramine dosage to a very high level, 5 mg/l or greater. That high a chloramine dosage level led to the formation of HAAs in the water distribution system. LAN proposed installing supplemental chloramine injection system at the City's pump stations. Once installed, the City could lower the initial chloramine dosage at the WTP. By operating their distribution system at a lower overall chloramine concentration level the City would be able to better control the formation of HAAs in the distribution system.

The cost of installing these chloramine booster injection systems was a major concern for the City. To reduce the cost of installing these systems, LAN approached this project somewhat differently than a standard design/bid project. First, LAN established a priority for installing the chloramine booster injection systems. That enabled the City to treat each installation as a completely separate system. LAN also worked with the City to identify tasks the City could complete with internal resources or existing "on-call" contracts. The technical specification prepared by LAN clearly stated tasks with the responsible party (contractor or City). That allowed the City to directly solicit cost proposals, greatly reducing the City's administrative costs on this project.

As a result of this project the City was able to reduce the concentration of HAAs in the water distribution system to allowable levels. As an added benefit, the City was able reduce its WTP operating costs because less chemicals are being used since the overall chloramine concentration in the treated drinking water is lower.

120-10215-000
Coastal Water Authority (CWA) Strategic Studies (Overall Description)

The Coastal Water Authority owns and/or operates a number of facilities to provide water to industrial and municipal customers, including the City of Houston. The major facilities include: the Trinity River Pump Station and main transfer canal (including major turnout), the Lynchburg Reservoir and pump station (which provides water through three large transmission mains), the Lake Houston dam, pump station, and West Canal (which provide water to numerous customers, including the City of Houston (EWPP) and an industrial process water treatment plant near the Houston ship channel.

Task 117 – Red Bluff Water Treatment Plant Upgrade
The Coastal Water Authority (CWA) owns and operates an industrial process water treatment plant on Red Bluff Road in Pasadena, TX (Red Bluff WTP). This facility utilizes the cold lime softening process followed by gravity filtration to provide the required quality of water to their customers. The equipment at this facility is more than 30 years old and some systems are in need of improvement or replacement. The standards for the process water have also recently been changed, resulting in a requirement for improved process control and for additional analytical testing and data reporting.

Lockwood, Andrews, & Newnam, Inc. (LAN) was retained to provide a preliminary engineering report (PER), detailed design, and bid/construction phase services for the improvements to achieve the goals of this project. This project includes the following improvements and replacements: a new gravity filter for process water; three replacement gravity filters for process water; a new sodium hypochlorite feed system to replace the existing gas chlorine system (to remove the component of risk management from this facility); a completely new SCADA system to replace the timer and relay driven master control panel – one to control not only the new components, but all existing components as well; and replacement of various system components (such as level transmitters and flow meters) that are no longer functioning and/or are obsolete.

The SCADA system was designed in coordination with Mbroh Engineering, Inc. (Mbroh). While LAN developed the majority of the control narratives during the PER phase, Mbroh took those control narratives and designed the SCADA system required to implement those strategies. Mbroh developed all instrumentation drawings, including wiring to all field devices, the PLC architecture, P&ID drawings for the new and/or replacement equipment, and the overall SCADA system architecture.
This project is presently in the bid phase and it is anticipated that the project will be completed by the end of 2010.

Task 471 – Lake Houston Pump Station, Water Intrusion Project
LAN conducted a site visit to investigate source(s) of moisture intrusion at the Lake Houston Pump Station and identify remedial action(s). LAN reviewed the findings and recommendations in Binkley & Barfield Report, Moreno Engineering Report, Molina Walker Architects Report and Blast, Inc. Report, and observation and investigations for possible other problems and potential solutions. LAN also prepared recommendations for maintenance and repairs for CWA approval. LAN is to prepare plans and specifications and Option of Probable Costs for CWA approval, assist CWA in the bid or proposal phase activities, provide construction phase observation and contract administration services and coordinate all project closeout activities and warranty activities.

130-10179-001
City Of Houston Groundwater Treatment Plant(s)

The City of Houston contracted Lockwood, Andrews & Newnam, Inc. (LAN) to provide professional engineering services for improvements at the City's groundwater treatment plants. The City is currently transitioning from groundwater to surface water and the plants are being repurposed for surface water distribution with groundwater as a backup. The project, currently underway, is organized into two phases. Under the completed Phase 1, LAN provided recommendations and professional services, including preliminary design documents for various improvements at ten groundwater plants. This included modification of chemical feed systems, addition of booster pumps, modification and replacement of electrical systems, addition of instrumentation, drainage improvements and driveway access.

Under Phase 2, LAN is currently providing preliminary and final design documents for the recommended improvements at five groundwater plants for the City. This includes modification of chemical feed systems, replacement of valve actuators, addition of booster pumps (1200 HP, 4160 V), replacement and rehabilitation of electrical systems including switchgear and motor control center replacement, replacement and programming of control system PLCs, reconfiguration of the SCADA system HMI for the associated changes, additional instrumentation, drainage improvements and driveway access.
Planning for the replacement of the switchgear at one of the sites is extremely critical as the plant supplies potable water to approximately one quarter of the City and cannot be out of service for more than a few hours.

A subsequent project will perform the modifications and upgrades at the remaining five plants in the report generated in phase 1.

Mbroh Engineering, Inc. (MEI) serves as a minority subconsultant on the project assisting LAN with electrical power and instrumentation design.

[illegible]
Surface Water System Hydraulic Analysis & Transient Modeling — City of Sugar Land, TX

LAN was retained to perform a hydraulic analysis and transient modeling services related to the City's proposed surface water transmission main system, which included a 22 MGD Surface Water Treatment Plant (SWTP) and transmission waterlines ranging in diameter from 16- to 36-inches.

<u>Hydraulic Analysis</u>
To assist the City's SWTP design engineer in pump selection, LAN developed system head curves, referred to as the transmission main dynamic head curves in this study, for the proposed surface water transmission system were developed from the fence line of the SWTP finished water pump station to the fence line of the existing groundwater plant facilities that will be used as surface water re-pump stations.

LAN created an EPANet hydraulic model of the City's proposed surface water transmission system to develop system curves. Fort Bend County LIDAR (elevation) data was used for estimating the transmission main elevations in the model. Since the surface water system was being design by three separate design firms – SWTP engineer, transmission waterline engineer, and surface water re-pump station engineer - elevation datums provided were compared and adjusted as necessary to perform the analysis on a consist basis.

The proposed surface water system is being constructed in two 11 MGD Phases – Phases I and II. Hydraulic analyses for the Phase I and Phase II surface water transmission system were developed based on flow operating scenarios provided by the City. Eight transmission main dynamic head curves were developed for all the operating scenarios to demonstrate the full range of transmission main dynamic head curves for the surface water transmission system.

Each transmission main dynamic head curve was developed by varying demands in maximum increments of 1,000 gpm. The flows to each groundwater plant were kept proportional based on the projected flows for each operating scenario when developing the transmission main dynamic head curves. A total of approximately 90 hydraulic model scenarios were analyzed for the various operating scenarios. All the transmission main dynamic head curves developed assume a minimum pressure of 30 psi at any groundwater plant fence line based on information provided the surface water re-pump station engineer. The minimum pressure of 30 psi is required at the fence line of each groundwater plant to account for head loss through yard piping, valves, metering station, and filling of ground storage tanks at the groundwater plants.

A transmission main dynamic head curve for each operating scenario was developed for the following three system conditions:
1. A pipeline C-value of 145
2. A pipeline C-value of 120
3. A pipeline C-value of 100

Based on the results of the surface water transmission system hydraulic analysis, the hydraulic grade line at the SWTP fence line required to meet the system flow requirements for the Phase I and Phase II scenario and provide the minimum of 30 psi at the groundwater fence lines for each of the scenarios.

Surface Water Treatment Plant Transient Analysis

LAN developed a detailed transient analysis model, utilizing the Liquid Transient (LIQT) software, of the City of Sugar Land's proposed Surface Water Treatment Plant (SWTP) finished water pump station from the ground storage tanks to the discharge piping header in order to determine closing and opening times for the pump control valves. The transient modeling included analysis of the worst case emergency conditions to determine if the type and location of surge protection devices within the SWTP are adequate for the treatment plant system. LAN worked with the SWTP design engineer to collect data related to the design and operation of the SWTP.

Using the data collected, the transient was developed for the SWTP to include:

- Suction side header and branch piping between the pumps and ground storage tanks
- All pumps and control valves
- Discharge branch and header piping

To analyze the system, hydraulic boundary conditions were developed to represent the flow to the various take-points. To protect the SWTP against the worst case transient conditions analyses were performed for the Phase II maximum firm pumping capacity of the SWTP.

Four scenarios were modeled for this study:

1. Normal pump start-up
2. Normal pump shutdown
3. Emergency shutdown - all SWTP pumps running and all failing simultaneously (i.e., total pump station power failure) [assumes firm pumping capacity]
4. Partial power failure – failure of one pump while remaining pumps continue to run [Assumes all pumps are the same size. If not, failure of the largest running pump will be considered.]

Based on the analyses results, valve closing and opening times for the control valves at the SWTP were recommended. Results were also used to determine the recommendations for minimizing positive (up-surge) and negative (down-surge) transient pressure occurrences at the SWTP, including the size and location of air vacuum valves and modifications to plant operational procedures. Analysis results were also used to illustrate there was no need for surge anticipator valves for the unique system providing cost savings to the City.

Transmission Waterline Transient Analysis

LAN developed a transient analysis model of the City of Sugar Land's proposed transmission main system from the Surface Water Treatment Plant (SWTP) finished water pump station to the ground storage tanks at the system take-points. The primary purpose of this transient modeling was to analyze the worst case conditions to determine the type and location of surge protection devices along the transmission mains to the Lakeview and First Colony No. 1 pump stations and at the surface water metering station (metering station). Analyses considered the Phase I and Phase II design flows. Although the SWTP was not modeled in as much detailed in these analyses as in the SWTP specific transient analyses, information from the SWTP analyses will be used as a basis for the transmission system.

LAN performed analyses to determine the minimum closure time of the flow control valve at the metering station to prevent high pressure surges from occurring in the transmission mains. LAN also recommended the type, size and location for air valves along the proposed transmission mains to protect the mains against worst case transient conditions and to fill and empty the mains.

The scenarios modeled included:

1. Emergency Pump Shutdown – Emergency shutdown of all SWTP pumps running and all failing simultaneously (i.e., total pump station power failure).
2. Normal Flow Control Valve Closure – Normal closure of the flow control valve at the Lakeview Water Plant metering station.
3. Emergency Flow Control Valve Closure – Emergency closure of the flow control valve at the Lakeview Water Plant metering station.

[illegible]
Dallas Water Utilities

LAN provided engineering services for Dallas Water Utilities to determine the appropriate facilities required to provide sludge handling and disposal and to design these facilities located at the East Side Water Treatment Plant. The East Side Water Treatment Plant has a treatment capacity of 400 million gallons per day (mgd) with an ultimate capacity of approximately 750 mgd. Raw water for the plant is provided by two reservoirs located north and east of the plant. The project goals to be addressed by LAN include providing on-site sludge disposal facilities with a minimum life span of 15 years and providing for a "zero" discharge of the process waters, recycling them back to head of the plant.

The Technical Memorandum prepared by LAN recommended that the sludge collected in the sedimentation basins be drained to a new sludge pump station, then pumped to the new sludge lagoons. The sludge lagoons consist of five cells located on approximately 80 acres south of the plant and have a total storage capacity of over 64 million cubic feet. This volume will provide well over 25 years of storage capacity for the treatment plant. Water flows from one lagoon to the next through a series of overflow weirs, then flows into an overflow structure in the fifth lagoon and drains back to the forebay at the head of the plant.

The filter backwash water will drain to a new 150-foot-diameter clarifier allowing for the fines to settle out through a continuous draw-off system and draining to the new sludge pump station. The effluent from the clarifier will flow into the existing sludge pump station, then will be pumped back to the forebay area utilizing the existing pumps. An overflow pump station was constructed adjacent to the new sludge pump station providing redundancy for both the new sludge pump station and the existing pump station ensuring a zero discharge system. The overflow pump station and sludge pump station will be wet wells utilizing submersible pumps and will have capacities of approximately 24 mgd and 18 mgd, respectively.
LAN also provided instrumentation design allowing for remote operations of all new facilities as required, as well as automation of the periodic draining of the sedimentation basins. Construction cost was estimated to be approximately $7.6 million. LAN provided a Technical Memorandum, design phase services, construction phase services, and start-up and operations assistance.

[illegible]
City of Houston's East Water Purification Plant #3

LAN provided construction management assistance for replacing the existing plant control system hardware at the City of Houston's East Water Purification Plant #3. The project included new PLC-based process control units with redundant communication links, workstations that maintain real time and historical databases of all processes in the process control units, and chemical feed control panels. The redundant plant control system workstations and non-redundant process control units monitor control the water plant's chemical feed system, filters, transfer pumps, and other unit processes. Additional work included the installation of new instrumentation, control valves, sample lines, conduit, wire, fiber optics equipment and related equipment for a complete functional plant control system.

LAN teamed with ESPA and Thompson Professional Group to provide extensive evaluations of the East Water Purification Plant that serves a large portion of the City of Houston. LAN's unique contribution to the team is the knowledge of modeling piping systems and the identification of the impact that different operational scenarios can make to system performance and cost. LAN provided the following services.

Hydraulic Analysis to:

1. Determine appropriate electrical power cost
2. Support review of existing operating conditions and establish new operation conditions
3. Support investigation of flow control alternatives (i.e., VFDs, control valves) and
4. Support investigation of pumping combinations to meet different system conditions and operate the three pumps to achieve maximum efficiency.
5. Compare and correlate operation of high service pumps to total plant electrical power cost using historic data to establish typical average and peak day operation.
6. Perform analysis to select a combination of pumps that achieves the best possible efficiency/power cost for assumed boundary conditions of tank level, discharge pressure and water demand.

7. Establish proper criteria to determine appropriate suction line, header, and cross over size. For example, average velocity, maximum velocity, CT, allowable headloss/suction head required at pump inlet, operation during emergency conditions, etc.
8. Simulate selected size(s) and arrangement of discharge header and associated piping to confirm satisfactory operation for the range of average day, peak day and emergency conditions anticipated. Identify bypass alternatives during various phases of construction. Include possibility of prolonged plant shut down.

Develop physical details of surge model for EWPP #1&2 and EWPP #3 including proposed improvements. Model included individual storage tanks, interconnecting piping, suction mains and headers, pumps with their control valves, existing and proposed surge protection devices, discharge headers and appropriate lengths of transmission mains.

Based on the proposed future operating conditions, identify possible causes of undesirable transients. Consider temporary conditions due to normal maintenance procedures that may increase probability or severity of transients.

The project included the study, design and construction of the pump station upgrade. LAN's role included the preliminary engineering, design engineering, architectural design, and construction management. LAN's unique contribution to the team is the knowledge of modeling piping systems and the identification of the impact that different operations scenarios can make to system performance and operations cost.

The hydraulic analyses provided valuable insight to the design team for reducing and managing operations cost for the facility. The analysis considered: existing operation conditions and established new operation conditions; investigation of flow control alternatives (i.e., VFDs, controls valves, etc.); evaluation of pumping combinations to meet different system conditions and operate the three pumps to achieve maximum efficiency; compare and correlate operation of high service pumps to total plant electrical power cost; and simulation of selected size(s) and arrangements of discharge header and associated piping to confirm satisfactory operation for the range of average day, peak day and emergency conditions anticipated.

Upon design completion, LAN provided construction management assistance, including a resident inspector, for the project. The construction management included installation of new PLC-based process control units with redundant communication links, workstations that maintain real time and historical databases of all processes in the process control units, and chemical feed control Panels. The redundant plant control system workstations and non-redundant process control units monitor and control the water plant's chemical feed system, filters, transfer pumps, and other unit processes. Additional work included the installation of new instrumentation, control valves, sample lines, conduit, wire, fiber optics equipment and related equipment for a complete functional plant control system. LAN also provided hydraulic modeling analysis, surge modeling, and a water quality analysis.

Water Quality Analysis

With the expansion of the City of Houston's surface water treatment capacity, the likelihood of mixing relatively hard ground water with soft surface water became a concern. As this mixing zone shifted due to water demand, industrial, commercial and residential customers would experience changing water quality. As part of the East Water Purification Plant Project, LAN conducted a water quality analysis to determine the extent of this problem. The analysis included determining the quality of both surface water sources and ground water sources; application of the Rynar and Langelier indexes to predict stability and the development of possible controls. The water quality analysis also addressed the effect of this mixing on disinfection.

Value Engineering Study of the East Water Purification Plant Reliability Improvements and Studies was also done to Increase Plant Capacity to 350 mgd.

[illegible]

WCID No. 2, the City of Missouri City, and the City of Sugar Land for a Surface Water Treatment

LAN was contracted to help in the development of a preliminary study of the requirements and options available to WCID No. 2, the City of Missouri City, and the City of Sugar Land for a surface water treatment plant to serve three cities' conversion from ground water to surface water. The effort was divided into five parts.

The initial part of this study involved collection of data and other studies and reports that relate to the existing and future water demand and impacts on the regional surface water supply. As part of this effort LAN included other efforts undertaken in Fort Bend County to examine surface water options and availabilities. Concurrent with that effort, under part two of this project, LAN updated the existing development and projected population growth and corresponding water usage within the service area. This effort was based on data provided by participants for desired service areas.

The third part of this project involved the development of preliminary costs for a projected surface water treatment plant. In developing those costs LAN worked to examine potential plant and raw water collection sites, transmission costs for raw and finished water, and construction and operational and maintenance costs for different treatment plant processes and configurations. The analysis considered a range of plant capacities in order to determine whether a certain capacity or phased construction was the most cost effective for the situation. Unit costs were developed based on full capacity of the plant.

LAN included an analysis of the current and projected legislative and regulatory issues pertinent to a surface water treatment plant. In this part of the study LAN also examined environmental concerns and the impact of locating such a plant within the City's current and future boundaries. This investigation applied to the plant site as well as required conveyance facilities.

In concluding this report LAN, presented a summary of the alternatives available to the City. The presentation highlighted economic, environmental, as well as political impacts of the alternatives examined. Financial implications of the various alternatives were also presented with this summary.

[illegible]

Mt. Carmel Water Plant

LAN provided architectural and mechanical/electrical/piping design support for the Mt. Carmel Water Plant, a 40 million gallon per day facility. This project replaced the existing chemical storage and feed equipment. Key design elements included chemical storage/feed and chlorine storage/feed buildings, an alum storage area, a demineralized water system, and improvements to various chemical injection points throughout the plant.

The new buildings provided improved storage areas, updated chemical feed equipment, integration of the chemical feed systems into the plant SCADA system, an improved electrical/control room, and equipment storage space. With the new chlorine storage/feed building, the plant has enclosed storage for all chlorine cylinders. The chlorine feed system was also converted from a pressure system to a safer vacuum feed system. Both buildings were designed to blend with the existing plant structures.

As part of this project, LAN examined the existing chemical injection points to determine whether the existing locations were at the optimum points in the plant. As a result of this examination, several chemical injection points were relocated to improve chemical residence times and mixing. These relocations not only increased the effectiveness of the chemicals from a treatment aspect, but also improved chemical use efficiency.

The City of Waco requested a compressed timeline, and LAN was able to quickly complete the design enabling construction to be completed on schedule.

[illegible]

Brazos Bend Water Authority Planning Study

LAN provided engineering services to the Brazos Bend Water Authority for a regional water supply and wastewater treatment plan. The Authority had been authorized to develop surface water supplies and wastewater treatment and disposal for a large portion of Brazoria and Fort Bend Counties comprised of the Cities of Pearland, Manvel, Brookside Village and Missouri City and their extraterritorial jurisdictions. Planning assistance was obtained from the Texas Water Development Board in the nature of a grant for half the plan cost and a loan for the matching local share. Based on population projections for a 50-year planning horizon, the study evaluated existing groundwater supplies and limitations, and investigated potential surface water resources.

The recommended plan provided estimated costs per 1000 gallons and included the cost of water, capital and operating costs, and supply, treatment and delivery system costs. The results of the study for the 150-square-mile service area recommended two water treatment plants with a total capacity of 30 mgd. The regional plan also recommended construction of more than 75 miles of water transmission mains varying in diameter from 8 to 36 inches. The estimated construction costs for the regional water plants and distribution facilities were approximately $120 million. The wastewater portion of the study recommended a single treatment plant with an ultimate capacity of 18.25 mgd. The planned collection facilities consisted of gravity sewer system varying in diameter from 12 to 48 inches, with in-line lift stations as required to limit depth. The proposed $115 million wastewater construction project included a phasing plan for the incremental construction of the plant and collection facilities as required to meet customer demand.

It was originally planned that the Authority would eventually provide wholesale services to the local municipalities and utility districts, thereby achieving efficient economical regional operations. As a result of this initial planning effort, LAN has since been selected by the City of Missouri City for planning and design of new collection and treatment facilities required for the consolidation of the numerous in-city Municipal Utility Districts and their associated facilities.

[illegible]

Gatesville Regional Water Supply

The Gatesville Regional Water Supply system with a capacity of 12 MGD provides treated water to the City of Gatesville (City), Flat WSC, The Grove WSC, Fort Gates WSC, Mountain WSC, Coryell City WSD, Texas Department of Criminal Justice, and the United States Army at North Fort Hood. The regional system is comprised of a raw water intake at Belton Lake in Bell County, Texas, 12 million gallon per day (MGD) surface water treatment plant, high service pump station, three booster pump stations, and four ground storage tanks.

Lockwood, Andrews, & Newnam, Inc. (LAN) was authorized by the City to provide the design, construction administration, and construction observation for improvements and additions to the existing filters at the Gatesville Regional Water Treatment Plant. The existing filters are rated for 12 MGD and have been in service over 20 years without any significant improvements. The improvements included replacement of the dual media in each of the four existing filters along with removal and replacement of the existing underdrains and the addition of two new dual media filters for a total filtering capacity of 16 MGD. New filter controls will be installed for both the existing filters and the proposed filters. The existing surface wash system for the existing filters will be removed while air scour was added to the back wash cycle. The project also included a blower bldg along with blowers for the air scour and valve rehabilitation of the existing valves.

The City of Gatesville requested that filter to waste be added to the existing filters along with including it in the design of the new filters. Upon review of the existing pipe gallery it was discovered that there was not available space to install piping to allow the filter to waste. LAN proposed to utilize the existing backwash line along with the backwash waste line as a filter to waste with a few piping modifications and the addition

of one valve. This allows the city to operate in their preferred manner without significant costs or upgrades.

The additional capacity along with the improvements of the existing filters will ensure the City of Gatesville and the surrounding areas have potable water over the next 20 years without any significant capital expenditures.

1296175-2-010

Surface Water Treatment Plant Options, Sugar Land, Texas

The City of Sugar Land engaged LAN to prepare a preliminary study of the requirements and options available for a surface water treatment plant to serve the city's conversion from groundwater to surface water. LAN previously completed a water master plan in 1996, an update of that plan in 2000, and a model of the city's existing water system production (groundwater), storage, and distribution. With this study LAN expanded upon that work to refine future water requirements as well as identify surface water options. The study area encompassed four master planned development communities, four state-owned land tracts, and six municipal utility districts not in the city's extra-territorial jurisdiction, but within a reasonable service area for a city operated water plant.

LAN organized this effort into five distinct parts:

- Collection and review of related data and studies
- Updating the current and future development projections
- Development of preliminary costs
- Analysis of the current and projected legislative and regulatory issues including environmental concerns
- Summary of the alternatives, highlighting economic, environmental, as well as political impacts

13-046

Lockwood,Andrews&Newnam **Motor & Repair Services**

CITY OF FLINT MICHIGAN

CONTRACTS

Contractor's Copy

EM SUBMISSION NO.: 2013 EM140

PRESENTED: 6-21-13

ADOPTED: 6-26-13

BY THE EMERGENCY MANAGER:

Resolution Authorizing Approval to Enter into a Professional Engineering Services Contract for the Implementation of Placing the Flint Water Plant into Operation

The City of Flint requires professional engineering services for assistance in placing the Flint Water Plant into operation using the Flint River as a primary drinking water source for approximately two years and then converting to KWA delivered lake water when available at a cost of $171,000.00; and

The City of Flint is seeking to enter into a sole source contract with Lockwood, Andrews & Newnam, Inc., with funding coming from the Utilities Administration FY14 account in 591-536.100-801.000; and

IT RESOLVED, That appropriate City Officials are authorized to enter into a Professional Engineering Services contract with Lockwood, Andrews & Newnam, Inc., for the administration of placing the Flint Water Plant into operation using the Flint River as a primary drinking water source at a cost of $171,000.00. Funding will come from the Utilities Administration FY14 account 591-536.100-801.000

APPROVED AS TO FORM:

for

Peter M. Bade, Chief Legal Officer

APPROVED AS TO FINANCE:

Jerry Ambrose, Finance Director

EM DISPOSITION:

ENACT ✓ FAIL

DATED 6-26-13

Edward J. Kurtz, Emergency Manager

CITY OF FLINT
CONTRACT WITH LOCKWOOD, ANDREWS, & NEWNAM INCORPORATED

The purpose of this agreement is to enter into a contract pertaining to the implementation of placing the City of Flint Water Plant into operation, the City of Flint (hereinafter "City") and Lockwood, Andrews, Newnam Inc., (hereinafter "Contractor").

Applicable Law: This contract shall be governed by and interpreted according to the laws of the State of Michigan pertaining to contracts made and to be performed in this state.

Arbitration: Contractor agrees to submit to arbitration all claims, counterclaims, disputes, and other matters in question arising out of or relating to this agreement, Contractor must request consent to arbitrate within 30 days from the date the Contractor knows or should have known the facts giving rise to the claim, dispute or question.

(a) Notice of demand for arbitration must be submitted to the City in writing within a reasonable time after the claim; dispute or other matter in question has arisen. A reasonable time is hereby determined to be 14 days from the date the party demanding the arbitration knows or should have known the facts giving rise to his claim, dispute or question. In no event may the demand for arbitration be made after the time when institution of legal or equitable proceedings based on such claim dispute or other matters in question would be barred by the applicable statute of limitation.

(b) Within 60 days from the date demand for arbitration is received by the City, each party shall inform Contractor whether it agrees to arbitrate. If the City does not consent, Contractor may proceed with an action in the appropriate court. If the City does consent, then within 30 days of the consent each party shall submit to the other the name of one person to serve as an arbitrator. The two arbitrators together shall then select a third person, the three together shall then serve as a panel in all proceedings. Any decision concurred in by a majority of the three shall be a final binding decision. The City's failure to respond to a timely, conforming request for arbitration is deemed consent to arbitration.

(c) The costs of the arbitration shall be spilt and borne equally between the parties and such costs are not subject to shifting by the arbitrator.

(d) The remedy for Contractor's failure to comply with this provision is dismissal of the action.

City Income Tax Withholding: Contractor and any subcontractor engaged in this contract shall withhold from each payment to his employees the City income tax on all of their compensation subject to tax, after giving effect to exemptions, as follows:

(a) Residents of the City:
At a rate equal to 1% of all compensation paid to the employee who is a resident of the City of Flint.

(b) Non-residents:
At a rate equal to 1/2% of the compensation paid to the employee for work done or services performed in the City of Flint.

These taxes shall be held in trust and paid over to the City of Flint in accordance with City ordinances and State law. Any failure to do so shall constitute a substantial and material breach of this contract.

Compensation: The City shall pay for such services as have been set forth herein, a contract price not to exceed $ 171,000.00 upon submission of proper invoices, releases, affidavits, and the like. Contractor recognizes that the City does not guarantee it will require any set amount of services. Contractor's services will be utilized as needed and as determined solely by the City of Flint. Contractor expressly recognizes that it has no right to payment of any amount exceeding $171,000.00. Contractor agrees that oral agreements by City officials to pay a greater amount are not binding.

1. Contractor shall submit itemized invoices for all services provided under this Agreement identifying:

(a) The date of service
(b) The name of person providing the service and a general description of the service provided.
(c) The unit rate and the total amount due.

Invoices shall be submitted to:

City of Flint
Accounts Payable
P.O. Box 246
Flint, MI 48501-0246

City of Flint
Utilities Department
4500 North Dort Highway
Flint, Michigan 48505

It is solely within the discretion of the City as to whether Contractor has provided a proper invoice. The City may require additional information or waive requirements as it sees fit. The City will notify the Contractor of any errors or lack of sufficient documentation within 14 days of receipt of the invoice.

Contract Documents: The invitation for bids, instructions to bidders, proposal, affidavit, addenda (if any), statement of bidder's qualifications (when required), general conditions, special conditions, performance bond, labor and material payment bond,

insurance certificates, technical specifications, and drawings, together with this agreement, form the contract, and they are as fully a part of the contract as if attached hereto or repeated herein.

Disclaimer of Contractual Relationship With Subcontractors: Nothing contained in the Contract Documents shall create any contractual relationship between the City and any Subcontractor or Sub-subcontractor.

Effective Date: This contract shall be effective upon the date that it is executed by all parties and presented to the City of Flint Clerk. This contract shall not extend beyond fiscal year 2013.

Certification, Licensing, Debarment, Suspension and Other Responsibilities: Contractor warrants and certifies that Contractor and/or any of its principals are properly certified and licensed to perform the duties required by this contract in accord with laws, rules, and regulations, and it not presently debarred, suspended, proposed for debarment or declared ineligible for the award of Federal contracts by any Federal agency. Contractor may not continue to or be compensated for any work performed during any time period where the debarment, suspension or ineligibility described above exists or may arise in the course of Contractor contractual relationship with the City. Failure to comply with this section constitutes a material breach of this Contract. Should it be determined that contractor performed work under this contract while non-compliance with this provision, Contractor agrees to reimburse the City for any costs that the City must repay to any and all entities.

Force Majeure: Neither party shall be responsible for damages or delays caused by Force Majeure or other events beyond the control of the other party and which could not reasonably have been anticipated or prevented. For purposes of this Agreement, Force Majeure includes, but is not limited to, adverse weather conditions, floods, epidemics, war, riot, strikes, lockouts, and other industrial disturbances; unknown site conditions, accidents, sabotage, fire, and acts of God. Should Force Majeure occur, the parties shall mutually agree on the terms and conditions upon which the services may continue.

Good Standing: Contractor must remain current and not be in default of any obligations due the City of Flint, including the payment of taxes, fines, penalties, licenses, or other monies due the City of Flint. Violations of this clause shall constitute a substantial and material breach of this contract. Such breach shall constitute good cause for the termination of this contract should the City of Flint decide to terminate on such basis.

Indemnification: To the fullest extent permitted by law, Contractor agrees to defend, pay on behalf of, indemnify, and hold harmless the City of Flint, its elected and appointed officials, employees and volunteers and other working on behalf of the City of Flint, including the Project Manager, against any and all claims, demands, suits, or losses, including all costs connected therewith, and for any damages which may be asserted, claimed, or recovered against or from the City of Flint, its elected and appointed officials,

employees, volunteers or others working on behalf of the City of Flint, by reason of personal injury, including bodily injury or death and/or property damage, including loss of use thereof, which may arise as a result of Contractor's acts, omissions, faults, and negligence or that of any of his employees, agents, and representatives in connection with the performance of this contract. Should the Contractor fail to indemnify the City in the above-mentioned circumstances, the City may exercise its option to deduct the cost that it incurs from the contract price forthwith.

Independent Contractor: No provision of this contract shall be construed as creating an employer-employee relationship. It is hereby expressly understood and agreed that Contractor is an "independent contractor" as that phrase has been defined and interpreted by the courts of the State of Michigan and, as such, Contractor is not entitled to any benefits not otherwise specified herein.

Insurance/Worker's Compensation: Contractor shall not commence work under this contract until he has procured and provided evidence of the insurance required under this section. All coverage shall be obtained from insurance companies licensed and authorized to do business in the State of Michigan unless otherwise approved by the City's Risk Manager. Policies shall be reviewed by the City's Risk Manager for completeness and limits of coverage. All coverage shall be with insurance carriers acceptable to the City of Flint. Contractor shall maintain the following insurance coverage for the duration of the contract.

(a) Commercial General Liability coverage of not less than one million dollars ($1,000,000) combined single limit with the City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers, named as "Additional Insureds." This coverage shall be written on an ISO occurrence basis form and shall include: Bodily Injury, Personal Injury, Property Damage, Contractual Liability, Products and Completed Operations, Independent Contractors; Broad Form Commercial General Liability Endorsement, (XCU) Exclusions deleted and a per contract aggregate coverage. This coverage shall be primary to the Additional Insureds, and not contributing with any other insurance or similar protection available to the Additional Insureds, whether said other available coverage be primary, contributing, or excess.

(b) Workers Compensation Insurance in accordance with Michigan statutory requirements, including Employers Liability coverage.

(c) Commercial Automobile Insurance in the amount of not less than $1,000,000 combined single limit per accident with the City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers, named as "Additional Insureds." This coverage shall be written on ISO business auto forms covering Automobile Liability, code "any auto."

(d) Professional Liability - Errors and Omissions. All projects involving the use of Architects, civil engineers, landscape design specialists, and other professional services must provide the City of Flint with evidence of Professional Liability coverage in an amount not less than one million dollars ($1,000,000). Evidence of this coverage must be provided for a minimum of three years after project completion. Any deductibles or self-insured retention must be declared to and approved by the City. In addition, the total dollar value of all claims paid out on the policy shall be declared. At the option of the City, either the insurer shall reduce or eliminate such deductibles or self-insured retention with respect to the City, its officials, employees, agents and volunteers; or Contractor shall procure a bond guaranteeing payment of losses and related investigation, claim, administration, and defense expenses.

Contractor shall furnish the City with two certificates of insurance for all coverage requested with original endorsements for those policies requiring the Additional Insureds. All certificates of insurance must provide the City of Flint with not less than 30 days advance written notice in the event of cancellation, non-payment of premium, non-renewal, or any material change in policy coverage. In addition, the wording "Endeavor to" and "but failure to mail such notice shall impose no obligation or liability of any kind upon the company, its agents or representatives" must be removed from the standard ACORD cancellation statement. These certificates must identify the City of Flint, Risk Management Division, as the "Certificate Holder." Contractor must provide, upon request, certified copies of all insurance policies. If any of the above polices are due to expire during the term of this contract, Contractor shall deliver renewal certificates and copies of the new policies to the City of Flint at least ten days prior to the expiration date. Contractor shall ensure that all subcontractors utilized obtain and maintain all insurance coverage required by this provision.

Laws and Ordinances: Contractor shall obey and abide by all of the laws, rules and regulations of the Federal Government, State of Michigan, Genesee County and the City of Flint, applicable to the performance of this agreement, including, but not limited to, labor laws, and laws regulating or applying to public improvements.

Modifications: Any modifications to this contract must be in writing and signed by the parties or the authorized employee, officer, board or council representative of the parties authorized to make such contractual modifications under State law and local ordinances.

No Third-Party Beneficiary: No contractor, subcontractor, mechanic, materialman, laborer, vendor, or other person dealing with the principal Contractor shall be, nor shall any of them be deemed to be, third-party beneficiaries of this contract, but each such person shall be deemed to have agreed (a) that they shall look to the principal Contractor as their sole source of recovery if not paid, and (b) except as otherwise agreed to by the principal Contractor and any such person in writing, they may not enter any claim or bring any such action against the City under any circumstances. Except as provided by law, or as otherwise agreed to in writing between the City and such person, each such

person shall be deemed to have waived in writing all rights to seek redress from the City under any circumstances whatsoever.

Non-Assignability: Contractor shall not assign or transfer any interest in this contract without the prior written consent of the City provided, however, that claims for money due or to become due to Contractor from the City under this contract may be assigned to a bank, trust company, or other financial institution without such approval. Notice of any such assignment or transfer shall be furnished promptly to the City.

Non-Disclosure/Confidentiality: Contractor agrees that the documents identified herein as the contract documents are confidential information intended for the sole use of the City and that Contractor will not disclose any such information, or in any other way make such documents public, without the express written approval of the City or the order of the court of appropriate jurisdiction or as required by the laws of the State of Michigan.

Non-Discrimination: Contractor shall not discriminate against any employee or applicant for employment with respect to hiring or tenure; terms, conditions, or privileges of employment; or any matter directly or indirectly related to employment, because of race, color, creed, religion, ancestry, national origin, age, sex, height, weight, disability or other physical impairment, marital status, or status with respect to public assistance.

Notices: Notices to the City of Flint shall be deemed sufficient if in writing and mailed, postage prepaid, addressed to **Brent Wright, Water Plant Supervisor, 4500 North Dort Highway, Flint, Michigan 48505** and **Inez Brown, City Clerk, City of Flint, 1101 S. Saginaw Street, Flint, Michigan 48502**, or to such other address as may be designated in writing by the City from time to time. Notices to Contractor shall be deemed sufficient if in writing and mailed, postage prepaid, addressed to **1 Oakbrook Terrace Suite 207, Oakbrook Terrace, Illinois 60181**, or to such other address as may be designated in writing by Contractor from time to time.

R-12 Prevailing Wages: Contractor is aware of City of Flint Resolution #R-12 dated April 8, 1991, which is hereby incorporated by reference, and agrees to abide by all of the applicable covenants and requirements set forth in said resolution.

Records Property of City: All documents, information, reports and the like prepared or generated by Contractor as a result of this contract shall become the sole property of the City of Flint.

Scope of Services: Contractor shall provide all of the materials, labor, equipment, supplies, machinery, tools, superintendence, insurance and other accessories and services necessary to complete the project in accordance with the proposals submitted on June 2013. Contractor shall perform the work in accordance with the Standard General Conditions and any Special Conditions provided for in this contract and warrants to the City that all materials and equipment furnished under this contract will be new unless otherwise specified, and that all work will be of good quality, free from faults and defects and in conformance with the contract documents. All work not conforming to these

requirements, including substitutions not properly approved and authorized, may be considered defective. In addition to any other remedies the City may have, if, within one year of the date of substantial completion of work, or within one year after acceptance by the City, or within such longer period of time as may be prescribed by law, any of the work is found to be defective or not in accord with the contract documents, Contractor shall correct promptly after receipt of a written notice from the City to do so, unless the City has previously given Contractor a written acceptance of such condition.

Severability: In the event that any provision contained herein shall be determined by a court or administrative tribunal to be contrary to a provision of state or federal law or to be unenforceable for any reason, then, to the extent necessary and possible to render the remainder of this Agreement enforceable, such provision may be modified or severed by such court or administrative tribunal so as to, as nearly as possible, carry out the intention of the parties hereto, considering the purpose of the entire Agreement in relation to such provision. The invalidation of one or more terms of this contract shall not affect the validity of the remaining terms.

Standards of Performance: Contractor agrees to exercise independent judgment and to perform its duties under this contract in accordance with sound professional practices. The City is relying upon the professional reputation, experience, certification, and ability of Contractor. Contractor agrees that all of the obligations required by him under this Contract shall be performed by him or by others employed by him and working under his direction and control. The continued effectiveness of this contract during its term or any renewal term shall be contingent upon Contractor maintaining his certification in accordance with the requirements of State law.

Subcontracting: No subcontract work, if permitted by the City, shall be started prior to the written approval of the subcontractor by the City. The City reserves the right to accept or reject any subcontractor.

Termination: This contract may be terminated by either party hereto by submitting a notice of termination to the other party. Such notice shall be in writing and shall be effective 30 days from the date it is submitted unless otherwise agreed to by the parties hereto. Contractor, upon receiving such notice and prorated payment upon termination of this contract shall give to the City all pertinent records, data, and information created up to the date of termination to which the City, under the terms of this contract, is entitled.

Time of Performance: Contractor's services shall commence immediately upon receipt of the notice to proceed and shall be carried out forthwith and without reasonable delay.

Union Compliance: Contractor agrees to comply with all regulations and requirements of any national or local union(s) that may have jurisdiction over any of the materials, facilities, services, or personnel to be furnished by the City.

Waiver: Failure of the City to insist upon strict compliance with any of the terms, covenants, or conditions of this Agreement shall not be deemed a waiver of any term,

covenant, or condition. Any waiver or relinquishment of any right or power hereunder at any one or more times shall not be deemed a waiver or relinquishment of that right or power at any other time.

Whole Agreement: This written agreement and the documents cited herein embody the entire agreement between the parties. Any additions, deletions or modifications hereto must be in writing and signed by both parties.

IN WITNESS WHEREOF, the parties have executed this contract this (day) of July, 2013.

CONTRACTOR:

Its Director of Engineering

WITNESS(ES):

CITY OF FLINT, a Michigan Municipal Corp.:

Michael K. Brown
Emergency Manager

APPROVED AS TO FORM:

for

Peter M. Bade
Chief Legal Officer

13-046B

Lockwood, Andrews&Newnam **Water Plant Operations**

CITY OF FLINT MICHIGAN

CONTRACTS

Contractor's Copy

13-5423

EM SUBMISSION NO.: EME0482013

PRESENTED: 11-14-13

ADOPTED: 11-18-13

BY THE EMERGENCY MANAGER:

Resolution Authorizing Change Order #2 to the Lockwood, Andrews & Newnam Contract for the Implementation of Water Plant Operations

The City of Flint entered into a contract with Lockwood, Andrews & Newnam to study the feasibility and develop cost estimates for utilizing the Water Plant as a primary drinking water source in an amount not to exceed $171,000.00; and

Authorization is needed to enter into change order #2 to the existing contract no. 13-046 with Lockwood, Andrews & Newnam for additional funding of $962,800.00 for a total contract price not –to-exceed $1,133,800.00. The additional services will include final design work, construction engineering and necessary regulatory submittals to operate the Water Plant off the river until the KWA water source is completed; and

These funds are made available in account in 591-536.100-801.000; and

IT RESOLVED, Appropriate City Officials are to do all things necessary to enter into change order #2 to the existing contract no. 13-046 with Lockwood, Andrews & Newnam for an additional contract price of $962,800.00 for a total contract price not-to-exceed $1,133,800.00. Funding will come from the account 591-536.100-801.000.

APPROVED AS TO FORM:

Peter M. Bade, Chief Legal Officer

APPROVED AS TO FINANCE:

Jerry Ambrose, Finance Director

EM DISPOSITION:

ENACT X **FAIL** ______ **DATED** 11-18-13

Darnell Earley, Emergency Manager

ORDER NO. ______________
DATE: ______________

AGREEMENT DATE: ______________

NAME OF PROJECT: Lockwood, Andrews, & Newnam Change Order #2

OWNER: City of Flint Utilities-Water Plant

CONTRACTOR: Lockwood, Andrews, & Newnam

THE FOLLOWING CHANGES ARE HEREBY MADE TO THE CONTRACT DOCUMENT:

Modify the scope of the contract to include additional services for final design work, construction engineering, and regulatory submittals to operate the Water Plant until KWA water source is completed not to exceed an amount of $962,800.00 for a revised total of $1,133,800.00

CHANGES TO CONTRACT PRICE

ORIGINAL CONTRACT PRICE:	$171,000.00
CURRENT CONTRACT PRICE ADJUSTED BY PREVIOUS CHANGES	$171,000.00
THE CONTRACT PRICE DUE TO THIS CHANGE WILL BE INCREASED BY	$962,800.00
THE NEW CONTRACT PRICE DUE TO THIS CHANGE WILL BE	$1,133,800.00

APPROVED:

AS TO FORM:

Peter M. Bade
CHIEF LEGAL OFFICER

ACCEPTED:

FIRM: **Lockwood, Andrews, & Newnam**

BY: ______________

TITLE: ______________

ADDRESS: One Oakbrook Terrace
Oakbrook Terrace, Illinois 60181

THE CITY OF FLINT,
A MUNCIPAL CORPORATION

BY: ______________________
Darnell Earley
EMERGENCY MANAGER

CITY OF FLINT, MICHIGAN
Department of Finance

Dayne Walling
Mayor

City Hall, Room #203
1101 South Saginaw Street
Flint, MI 48502
(810) 766-7268 / (810) 766-8675 (fax)

Darnell Earley
Emergency Manager

Gerald Ambrose
Finance Director

TO: Darnell Earley
Emergency Manager

FROM: Jerry Ambrose
Finance Director

DATE: November 14, 2013

SUBJECT: Resolution Authorizing a Change Order to the Contract with Lockwood, Andrews and Newman to provide for final design work, construction engineering and necessary regulatory submittals related to the expansion of the Water Treatment Plant

LAN was retained earlier this year with approval from the Department of Treasury at a cost of $171,000 to study the feasibility of utilizing the Flint River as the City's source of water on a temporary basis, and to develop preliminary associated cost estimates for expanding the Water Treatment Plant.

LAN's work concluded that using the Flint River on a temporary basis only was feasible, and provided a cost estimate of between $7 million and $10 million, depending on the expenses associated with lime disposal. However, their work also concluded that work must begin immediately if the April 2014 deadline is to be met.

Accordingly, LAN was requested to provide us with a proposal for conducting final design work, construction engineering, and necessary regulatory submittals associated with the expansion of the Water Treatment Plant. Their proposal is for an amount not to exceed $962,800.

We have been working with MDEQ to be assured that the course of action being pursued is consistent with their expectations. Most recently (this morning), we met with MDEQ representatives and reviewed the proposed course of action. While formal approval cannot be given until detailed working drawings are presented, the representatives indicated their conceptual approval.

Because time is of the essence, I recommend approval of the Change Order, and request that it be submitted to Treasury as soon as possible. I am attaching LAN's Scope of Work proposal, as well as a letter from Rowe Engineering stating that the Scope of Work is comprehensive and the price is reasonable.

Please contact me if you have any questions.

ROWE PROFESSIONAL SERVICES COMPANY

Large Firm Resources. Personal Attention.℠

November 13, 2013

Mr. Daugherty Johnson
City of Flint – Utilities
City Hall
1101 S. Saginaw Street
Flint, MI 48502

RE: WTP Proposal/Expenditures Review

Mr. Johnson:

I have completed the review of the scope of services and associated fee for the above referenced project and have found everything to be in line with industry standards for this type of project.

The proposal submitted by LAN (Lockwood, Andrews, & Newnam, Inc.) is all inclusive and the fee is within the appropriate percentage of construction (~5%) that is consistent with these types of projects.

Respectfully submitted,
ROWE Professional Services Company

Rick A. Freeman, P.E.

Rick A. Freeman, P.E.
Senior Project Manager

Proposed Scope of Upgrades to Flint WTP

Phase II - Segments I & II

1. Introduction

The City of Flint plans to utilize their existing WTP to provide water on a continuous basis. The city plans to treat water from the Flint River until construction of the proposed KWA supply is complete and the WTP can then be used to treat water from Lake Huron. The following proposed improvements are needed to place the WTP into service next spring. These improvements will remain in service once the KWA is in service.

2. Scope of Work

The proposed upgrades have been categorized into Phase II – Segment I and are to be completed as soon as practical so that the WTP can be utilized to treat water from the river in the spring of 2014. Engineering services will include final design, plans, contract documents, bidding assistance. Since time is of importance, specifications and schematic drawings will also be provided for pre-procurement of long lead item equipment and are outlined within each section below. Contract administration and construction phase services are not included within the initial scope of services.

- Design Progress Meetings: Meet with City staff to provide project status updates and to discuss specific design issues and details in order to facilitate timely design decisions. Meetings will include design team personnel from each discipline as required, City operations staff and administrative staff. Five (5) design progress meetings are included.
- Prepare and update opinion of probable construction cost at for each project bidding document submittal (40%, 80% and Final Draft). Prepare final opinion of probable construction cost prior to bidding.
- Quality Assurance/Quality Control: A Quality Control Plan (QCP) will be developed and implemented specifically for this project. At each project submittal stage, the document deliverables will be checked and reviewed by experienced personnel to ensure that the design meets applicable standards and normal engineering practice.
- Deliverables:
  40% Bidding Documents (Drawings and Technical Specification Outline)
  80% Bidding Documents (Drawings and Technical Specifications)
  Final Draft Bidding Documents (Drawings and Technical Specifications)
  Final Bidding Documents (One printed and one electronic set of Drawings and Technical Specifications
- Bidding Phase
  Conduct pre-bid meeting.
  Respond to contractor inquiries.
  Prepare construction document addenda, as necessary.

Review bids and supporting bid documentation. Prepare bid report summarizing bids, contractor references, and contractor qualifications; make recommendation for contract award.

- Construction Phase

  Review and respond to contractor submittals (First two reviews are included in level of effort, subsequent review cost will be paid for by contractor)

  Respond to contractor's request for information

  Prepare monthly payment documents

  Negotiate and prepare change orders for client review and approval

  Attend monthly project meetings

  Provide periodic onsite technical observer (have included two weeks per month in level of effort)

  Develop record documents (provide one hard and one electronic copy to owner)

Specific Work Tasks:

Item 1 – Chemical Systems / Ozone

The Michigan Department of Environmental Quality (MDEQ) requires 30 days of redundant storage of the chemical used in this treatment process. To bring the rehabilitated plant into regulatory compliance with the chemical storage requirements for primary use, additional storage facilities will need to be constructed for liquid oxygen and nitrogen.

One liquid oxygen and one liquid nitrogen storage tanks and unloading stations identical to the existing units will be installed north of the existing facilities. Details are listed as follows:

- Liquid Oxygen
  Capacity – 9000 gallons
  Diameter – 10 ft (maximum)

  Liquid Nitrogen
  Capacity – 540 gallons
  Diameter –5.5 ft (maximum)

Pre-procurement documents for the liquid oxygen and nitrogen tanks will be provided.

Item 2 – Electrical

The City of Flint Water Treatment Plant (WTP) represents a combination of administrative, process, and maintenance facilities which all require electrical power. At the completion of Phase I of the water treatment plant rehabilitation projects, much of the electrical distribution equipment such as motor control centers (MCCs), power/lighting panels, transformers, and electrical power feeders will have been upgraded. There is, however, significant additional work required to address remaining electrical equipment that has reached a point of obsolescence.

Switchgear in the sub-station was installed around 1960. It is antiquated and difficult to maintain. Very little work has been done to the station since its original installation. The plant has two 46 kV primary feeds into the sub-station. Replacement of the distribution switchgear with current technology

equipment would allow a higher degree of load protection, be serviceable by numerous sources, and have replacement parts availability. When the switchgear is replaced, the plant will have to stay in operation. Brief interruptions of power of selected plant processes could be accommodated during cut over to new equipment.

Proposed Substation Upgrade

- Coordinate upgrades to Consumers 46kV primary feeders to provide a single overhead 46KV primary service
- Replace the two Consumers 2.5kVA substation transformers and overhead structure with two 2.0 to 2.5 kVA 46KV pad-mounted transformers.
- Replace the City's substation switchgear in the substation building.

Pre-procurement documents for the pad mounted transformers and switchgear will be provided.

Pump Station No.4 contains the largest electrical loads in the plant. Four low service pumps and five high service pumps represent a combined total of approximately 4000 horsepower. Additional loads from HVAC, lighting, controls, and chemical feed are about 60 kVA. This represents a total load of 531 amps @ 2400 volts. The existing switchgear in Pump Station No.4 is antiquated and difficult to maintain. Current technology equipment will allow a higher degree of load protection.

Proposed Pump Station No. 4 Improvements

- Replace 2400V switchgear
- Provide one 15 MGD medium voltage VFD

Pre-procurement documents for the medium voltage VFD and switchgear will be provided.

As a base load facility capable of producing water at any time the Flint WTP must have the ability to deal with power outages. In order to meet these electrical need in the event of a loss of power to the plant site or the loss of one of the substation transformers a new standby diesel generator is proposed to be located adjacent to the new substation.

Proposed Standby Power Improvements

- One 2.0 to 2.5 mVA generators and fuel tank.

Pre-procurement documents for the generator set will be provided.

There are four 2400V to 480V transformers in Plant 2 that are antiquated and difficult to maintain. Replacement parts are no longer available and reliability is questionable.

Proposed Plant 2 Improvements

- Replace two 300kVA 2.4KV transformer/switchgear.
- Replace two 100kVA 2.4KV transformer/switchgear.

Pre-procurement documents for the transformers and switchgear will be provided.

Item 3 – Mid-Point Chlorination

Mid-point chlorination facilities are proposed to increase reliability of the disinfection process and improve Ct. For this initial stage the existing chlorine equipment in Pump Station No. 4 will be used and a new chlorine solution line will be installed from Pump Station No. 4 to the filter influent channel in Plant 2. A chlorine scrubber system will be installed in Pump Station No.4 to protect against a leaking chlorine ton container.

Proposed Chlorine Improvements

- New chlorine solution line to filter gallery.
- Chlorine system improvements.
- Dry scrubber system.

Item 4 – Low and High Service Pump Station No. 4

As a result of decreased demands, pumps at Pump Station No. 4 are "over-sized" and do not efficiently operate. Some of the pumps experience vibrations in the shafts and steady bearings. The existing pump station will be rehabilitated to replace "over-sized" pumps and obsolete equipment and provide needed maintenance.

Proposed Pump Station No. 4 Improvements

- Install one new High Service Pump (15 MGD @190 feet TH, vertically mounted pumps with 800 HP 2400/4160 V inverter duty motors, with 20 feet of shaft and steady bearings)
- Replacement of existing piping, valves, supports, and bearings
- New intermediate platforms, ladders, & stairs
- New ventilation (for exhausting heat from VFD's)
- Demolition of existing equipment to accommodate new equipment

Pre-procurement documents for the pump, motor, control valves and isolation valves will be provided.

Item 5 – Raw Water Piping Connection

The proposed KWA raw water pipeline will connect to the existing 72" PCCP finished water supply line near Center and Pierson Roads. (East of this connection, the 72" PCCP will be utilized by GCDC-WWS for distribution of finished water in the GCDC-WWS service area.) Raw water from Lake Huron will be conveyed to the WTP site via the 72" PCCP pipeline. On the WTP site, the 72" pipeline will be tapped for a 42" pipe and for a 36" pipe to convey raw water for treatment. Connections to the existing pipe will be made at this time to avoid future plant shutdowns for connections.

Proposed Pump Station No. 4 Improvements

- 48-inch pipe connections
- 36-inch pipe connection
- 54-inch pipe connection

Pre-procurement documents for the valves and connection fittings will be provided.

Phase II – Segment II:

The proposed upgrade for item 6 has been categorized as Phase II – Segment II and is to be completed with the same urgency as the rest of the work so that the WTP can be utilized to treat water from the river in the spring of 2014. However, the use of the Bray Road lagoon for other disposal activities will require that this issue be addressed independently to certain extent as to isolate the problem areas while working with MDEQ to permit its use for lime sludge disposal.

Item 6 – Softening Residuals Disposal

Develop, evaluate, design and implement a lime residuals disposal plan to handle softening sludge for the interim period of operation using the Flint River as a water source. These options may include the use of Bray Road lagoon, construction of temporary dewatering and loading facilities, and other temporary storage options.

The use of Bray Road Lagoon will require additional survey, geotechnical and environmental testing at the site in order to assess the condition of the lime sludge in the basin and to verify the capacity of the lagoon system. Based on the findings of this evaluation, proposed improvements will be designed to accommodate the use of the facility in the interim basis while addressing some of the MDEQ concerns about the site and any unauthorized discharges into the nearby stream. Permitting for site use will be incorporated as part of the overall design improvements at the WTP and submitted to the MDEQ at the 80% design stage for their pre-permit review and comments. A final package will be submitted to the MDEQ at the 100% design stage for permit issuance and approval of work plan.

Pre-procurement documents for specific equipment may be provided as needed.

3. Schedule

The work included in this work authorization is anticipated to be performed in accordance with the following schedule, based on the Notice-To-Proceed (NTP) date of November 1, 2013. For the purposes of this proposal, we anticipate a 3 month design phase and 1 month bid phase. Schedule revisions may be necessary as information becomes available and work priorities change.

Project Milestone	Date
Project Kickoff Meeting	November 6, 2013
Equipment Procurement Documents	December 6, 2013
Submit 40% Bidding Documents	December 18, 2013
Submit 80% Bidding Documents	January 10, 2014
Submit Final Draft Bidding Documents	January 31, 2013
Submit Final Bidding Documents	February 7, 2014
Bid Advertising	February 10, 2014
Pre-Bid Meeting	February 17, 2014
Bid Opening	TBD by City
Recommendation of Contract	TBD by City
Contract Award issued by City	TBD by City

4. Compensation

The Reimbursable Compensation method with a maximum not-to-exceed limit will be used for this contract. Labor rates shall be based on personnel classifications according to the existing rate sheet. Reimbursable expenses shall be invoiced at the actual cost times a factor of 1.0 for processing and handling. The estimated maximum not-to-exceed fee for this project is $962,800 which includes a $15,000 allowance for surveying and $15,000 allowance for geotechnical services.

Description	Fee
Design and Bidding Assistance	$ 752,800
Surveying Allowance	$ 15,000
Geotechnical Allowance	$ 15,000
Construction Phase Services	$ 180,000
Total Maximum Not to Exceed Fee	**$ 962,800**

Any other work beyond the Scope of Services herein will require a subsequent Work Authorization with prior approval from the City.

Lockwood, Andrews&Newnam

13-046B

Water Plant Operations

Change Order #3

CITY OF FLINT MICHIGAN

CONTRACTS

Contractor's Copy

EM SUBMISSION NO.: EME 573 2014

PRESENTED: 10-17-14

ADOPTED: 10-23-14

BY THE EMERGENCY MANAGER:

Resolution Authorizing Change Order #3 to the Lockwood, Andrews & Newnam Contract for the Implementation of Water Plant Operations

The City of Flint entered into a change order #2 contract with Lockwood, Andrews & Newnam to study the feasibility and develop cost estimates for utilizing the Water Plant as a primary drinking water source in an amount not to exceed $962,800.00 for a total contract price of $1,133,800.00; and

Authorization is needed to enter into change order #3 to the existing contract no. 13-046A with Lockwood, Andrews & Newnam, for additional design and testing services. Additional funding in the amount of $244,900.00 is required for a total contract price not -to-exceed $1,378,700.00; and

These funds are made available in account in 591-536.100-801.000; and

IT RESOLVED, Appropriate City Officials are to do all things necessary to enter into change order #3 to the existing contract no. 13-046A with Lockwood, Andrews & Newnam in the amount of $244,900.00 for a total contract price not-to-exceed $1,378,700.00 Funding will come from the account 591-536.100-801.000.

APPROVED AS TO FORM:

For

Peter M. Bade, Chief Legal Officer

APPROVED AS TO FINANCE:

for

Jerry Ambrose, Finance Director

EM DISPOSITION:

ENACT ✓ **FAIL** ______ **DATED** 10-23-14

Darnell Earley, Emergency Manager

ORDER N ______________
DATE: ______________

AGREEMENT DATE: ______________

NAME OF PROJECT: Implementation of Water Plant Operations

OWNER: City of Flint Utilities-Water Plant

CONTRACTOR: Lockwood, Andrews & Newnam

THE FOLLOWING CHANGES ARE HEREBY MADE TO THE CONTRACT DOCUMENT:

Modify the scope of the contract to include additional services for additional design and testing services for the implantation upgrade at the Water Plant not to exceed an amount of $244,900.00 for a revised total of $1,378,700.00

CHANGES TO CONTRACT PRICE

ORIGINAL CONTRACT PRICE:	$ 171,000.00
CURRENT CONTRACT PRICE ADJUSTED BY PREVIOUS CHANGES	$ 962,800.00
THE CONTRACT PRICE DUE TO THIS CHANGE WILL BE INCREASED BY	$ 244,900.00
THE NEW CONTRACT PRICE DUE TO THIS CHANGE WILL BE	$1,378,700.00

APPROVED:

AS TO FORM:

FOR

Peter M. Bade
CHIEF LEGAL OFFICER

ACCEPTED:

FIRM: **Lockwood, Andrews & Newnam**

BY: Warren

TITLE: Director of Engineering

ADDRESS 1 Oakbrook Terrace Ste.207
Oakbrook Terrace,IL 60181

THE CITY OF FLINT,
A MUNCIPAL CORPORATION

BY: Darnell Earley
Darnell Earley
EMERGENCY MANAGER

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Client Additional Services Authorization

Date: 6-6-14

Project Name Flint WTP Phase II Segment I Initial Watermain Cut-in Flint WTP Ph II-Seg II - Lime Residual Disposal Flint WTP Ph II-Seg III - Electrical Improvements	**Additional Services Authorization No.**
Client Name City of Flint	**To Project No.** 130-10701-001
Subject of Additional Services	**Original Contract Date** 6-26-2013

Description Provide additional services for the three projects listed above associated with:
1- Survey Pickup and Design changes required as part of the MDEQ permitting requirements and Consent Order; ($18,448.50)
2- Survey Pickup and Design Modifications with regard to Consumers Energy - FEE Strip and easement requirements at the WTP and Bray Road projects; ($20,715.50)
3- Chlorine Room Delivery System Design Improvements; ($12,950)
4- Construction Management Services for all above projects. ($72,786.00)
5- Treatability Study at the Plant to help with Operational & Quality Issues-2 staff members for two months ($76,000)
6- TTHM Report to address MDEQ issues that needs to be submitted quickly ($24,000)
7- Design Assistance during Construction to help with operational issues ($20,000)

Reason for Change 1) Modificaions to the design elements were required as part of MDEQ Permitting Requirements associated with the NPDES Permit and Consent Order Issued for the WTP Operation as a full time basis. 2) Coordination and deign changes associated with conflicts related to the Consumers Energy newfound Fee Strip and new required easements for the new service both at the WTP and the Bray Road sites. 3) Provide design changes to address upgrades to the Chlorine delivery system at PS4 for new chlorine tanks. 4) Manage construction activities on behalf of the City with the selected contractors on all three projects. 5) Treatability study -Bench Scale Testing. 6) TTHM Report to MDEQ 7)Design Assistance.

Compensation:

☐ Will be an amount equal to _____ times Salary Cost plus reimbursable expenses, both defined in the **PROFESSIONAL SERVICES AGREEMENT**, and in addition to the compensation for **BASIC SERVICES**. Total charges for these **ADDITIONAL SERVICES** are estimated to be approximately $_____.

☐ Will be the lump sum of $_____ for these **ADDITIONAL SERVICES**.

☒ Other Cost plus based on current rates for a NTE amount of $244,900.00 (use reverse if necessary)

Completion:

Current Date 6-15-14

This Extension 12 months

New Date 6-14-15

All terms and conditions of the original agreement remain in full force and effect.

Proposed By: Lockwood, Andrews & Newnam, Inc.

Warren Green, PE — Print Name/Title — Signature — 10-8-14 Date

City of Flint
Client

Approved By

Print Name/Title — Signature — Date

Execute in duplicate – (1) copy to Client, (1) copy to Accounting

Completion:	Current Date	12-30-15
	This Extension	18 months
	New Date	7-1-17

All terms and conditions of the original agreement remain in full force and effect.

Proposed By:	Lockwood, Andrews & Newnam, Inc.		
	Warren Green, PE		10-6-15
	Print Name/Title	Signature	Date
	City of Flint		
Approved By	Client		
	Print Name/Title	Signature	Date

Execute in duplicate – (1) copy to Client, (1) copy to Accounting

C-026-90

13-046D

Lockwood, Andrews&Newnam

Water Plant Operations
Change Order#4 (GAC filters)

CITY OF FLINT
MICHIGAN

CONTRACTS

LAN's Copy

EM SUBMISSION NO.: EMA 1572015

PRESENTED: 4-9-15

ADOPTED: 4-14-15

RESOLUTION AUTHORIZING APPROPIRATE CITY OFFICIALS TO ENTER INTO

CHANGE ORDER #4 WITH LOCKWOOD, ANDREWS, & NEWNAM

BY THE EMERGENCY MANAGER:

The City of Flint Department of Public Works & Utilities (DPW & Utilities) entered into a contract with Lockwood, Andrews, and Newnam to study the feasibility and develop cost estimates for the Water Plant as a primary drinking water source in a contract amount not to exceed $1,378,700.00; and

The DPW & Utilities through recommendations of Veolia North America water consultants have identified additional services due to TTHM concerns. The additional services will provide a turn key system of new GAC media in the twelve (12) filters at the Flint Water Plant including MDEQ permitting. The focus will be to provide design, procurement, and construction implementation services for upgrading the filters to address TTHM. The additional cost for these services is not to exceed $1,601,740.00. Funding for said services will come from the following account: 591-545.300-801.000; and

IT IS RESOLVED, that the appropriate City of Flint officials, upon the Emergency Manager's approval, is authorized to enter into change order #4 with Lockwood, Andrews and Newnam, for additional design, procurement, and construction services, not to exceed $1,601,740.00, for a total revised contract price of $2,980,440.00.

APPROVED AS TO FORM:

Peter M. Bade, City Attorney

Natasha L. Henderson, City Administrator

APPROVED AS TO FINANCE:

Dawn Steele, Deputy Finance Director

EM DISPOSITION:

ENACT X REFER TO COUNCIL FAIL ______

Gerald Ambrose, Emergency Manager

DATED: 4/14/15

ORDER N. ______________
DATE: ______________

AGREEMENT DATE: ______________

NAME OF PROJECT: Water Plant Operations C/O#4

OWNER: City of Flint Utilities Department

CONTRACTOR: Lockwood, Andrews, and Newnam

THE FOLLOWING CHANGES ARE HEREBY MADE TO THE CONTRACT DOCUMENT:

Modify the scope of the contract to include additional services to provide a turn- key system of new GAC media in the twelve (12) filters at the Water Plant not to exceed $1,601,740.00 for a revised total of $2,980,440.00

CHANGES TO CONTRACT PRICE

ORIGINAL CONTRACT PRICE:	$962,800.00
CURRENT CONTRACT PRICE ADJUSTED BY PREVIOUS CHANGES	$1,378,700.00
THE CONTRACT PRICE DUE TO THIS CHANGE WILL BE INCREASED BY	$1,601,740.00
THE NEW CONTRACT PRICE DUE TO THIS CHANGE WILL BE	$2,980,440.00

APPROVED:

AS TO FORM:

For

Peter M. Bade
CHIEF LEGAL OFFICER

ACCEPTED:

FIRM: Lockwood, Andrews, & Newnam

BY: ______________

TITLE: ______________

ADDRESS: 1 Oakbrook Terrace Suite207
Oakbrook Terrace, Illinois 60181

THE CITY OF FLINT,
A MUNCIPAL CORPORATION

BY: ______________
Gerald Ambrose
EMERGENCY MANAGER

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Client Additional Services Authorization

Date: 4-7-15

Project Name Flint WTP Phase II Segment I Initial Watermain Cut-in Flint WTP Phase II Segment I Rehab Flint WTP Ph II-Seg II - Lime Residual Disposal	**Additional Services Authorization No.**
Client Name City of Flint	**To Project No.** 130-10701-001
Subject of Additional Services	**Original Contract Date**

Description

Deliver a new GAC media to replace current anthracite media in the 12 filters at the Flint Water Treatment Plant (FWTP) through design-construction management at agency services. The purpose of the project will to be replace the existing filter system with a new GAC media in order to assist the city in addressing TTHM concerns as detailed in the "Flint, Michigan Water Quality Report" dated March 12, 2015 by Veolia North America (Veoila Report). The services shall include:

1- Design the GAC Filter replacement for the FWTP, which will include assisting the City in obtaining the necessary MDEQ Permit(s) and providing construction oversight; ($147,840.00)
2- Provide construction management at agency services for the removal of the existing media and the installation of the GAC filter at the FWTP. On behalf of the City, as City's CM Agent, engage a vendor that will procure new GAC Media, remove existing 18" anthracite and replace it with the new 18" GAC; (approximately $1,300,000.00)
3- Set up, upgrade and calibrate the Flint Distribution Water System to include field Tesing Verification and Support in order to analyze system perfomance and water age mapping and assist the City with line flushing/and or Ice Pigging Program; ($99,900.00)
4- Project Engineering Services to assist the City with monitoring and coordinating activities with city staff, MDEQ and vendors during the maintenance and implementation of improvements needed thru the August TTHM Sampling period. Services will be provided based on 60 hours/month for a total of five (5) months period; ($54,000)

Reason for Change

1) Pursuant to the Veolia Report replacing the anthracite in the filters with new GAC Media will assist in lowering the levels of TTHM. The replacement of the existing filter requires the performance of CT Analyses, conducting an evaluation of Hydraulic Loading and Backwash Capacities of the new GAC cross section, and meeting and coordinating with MDEQ to obtain MDEQ's approval of changes to the current permit;
2) In addition to the design, the replacement requires managing, on behalf of the City, the construction services of a vendor to implement design improvements of the filter system upgrade to the GAC media.
3) Modificaions to the hydraulic model are needed to upgrade the model and calibrate actual system performance and operation to include valve operational performance based on Service Center Report.
4) Provide a project engineer to work with the City, MDEQ and the vendors will assist in implementing Veolia's recommendations to the extent accepted by the City. Such engineering services will provide weekly progress reports to the City allowing the City to monitor the progress of the Project.

Compensation:

☐ Will be an amount equal to _____ times Salary Cost plus reimbursable expenses, both defined in the **PROFESSIONAL SERVICES AGREEMENT**, and in addition to the compensation for **BASIC SERVICES**. Total charges for these **ADDITIONAL SERVICES** are estimated to be approximately $_____.

☐ Will be the lump sum of $_____ for these **ADDITIONAL SERVICES**.

☒ Other Cost plus based on current rates for a Not-To Exceed amount of $1,601,740.00 (use reverse if necessary)

Completion:	Current Date	6-15-14		
	This Extension	3 months		
	New Date	9-15-15		
All terms and conditions of the original agreement remain in full force and effect.				
Proposed By:	Lockwood, Andrews & Newnam, Inc.			
	Warren Green, PE			4-7-15
	Print Name/Title		Signature	Date
	City of Flint			
Approved By	Client			
	Print Name/Title		Signature	Date
Execute in duplicate – (1) copy to Client, (1) copy to Accounting				

C-026-90

NAME OF PROJECT: Flint Water Treatment Plant Improvements – LAN Change Order #4.

OWNER: City of Flint Utilities- Water Plant

CONTRACTOR: Lockwood Andrews & Newnam, Inc. ("Engineer")

THE FOLLOWING CHANGES ARE HEREBY MADE TO THE CONTRACT DOCUMENT:

Modify the scope of the contract to include additional services related to the design, removal of the existing anthracite media in the 12 filters at the Flint Water Treatment Plant ("FWTP") and replacement with new GAC media ("Project") as described in more detail below under Section 1.0, Additional Services, subject to Section 2.0, Additional Terms and Conditions provided below for the Not-to Exceed amount of $1,601,740.00 for a revised total of $2,980,440.00 , as described in more detail below under Section 3.0, Changes to Contract Price.

1.0 ADDITIONAL SERVICES. To the extent provided below, Engineer shall (a) design the removal of anthracite media and replacement with a new GAC media in all the 12 filters at the FWTP; and (b) provide Construction management as an Agent not at risk services ("CMA Services") for the construction related to the removal of existing media and installation of the new GAC media in the 12 filters at the FWTP

1.1 Design Services.

1.1.1 Design the GAC Filter replacement for the FWTP, which will include assisting the City in obtaining the necessary MDEQ Permit(s) and providing construction oversight

1.1.1.1 Evaluate and Provide design elements associated with implementing the filter change out to GAC.

1.1.1.2 Coordinate with MDEQ design elements and get their approval to anticipated design changes.

1.1.1.3 Review Veolia's information and develop CT analysis to verify design changes will meet MDEQ requirements.

1.1.1.4 Meet with the City and MDEQ to assist in obtaining MDEQ's approval to proceed.

1.1.1.5 Assist the City if overseeing the implementation of the system change out in the filters.

1.1.1.6 Coordinate with the contractor to assist in contractor's understanding of design intent.

1.1.2 Set up, upgrade and calibrate the Flint Distribution Water System to include field Tesing Verification and Support in order to analyze system perfomance and water age mapping and assist the City with line flushing/and or Ice Pigging Program.

1.1.2.1 Verify transmission and distribution piping system using City's GIS, including pipe diameters
1.1.2.2 Verify pipe C-factors
1.1.2.3 Verify transmission and distribution system connections
1.1.2.4 Verify facilities' piping for Filter plant and pumping stations, including piping layout, diameters and C-factors (use record drawings for piping)
1.1.2.5 Obtain existing pump curves and motor data to confirm information in the model
1.1.2.6 Confirm storage facility data, including volume and tank levels
1.1.2.7 Spot check elevations for distribution system and facilities
1.1.2.8 Obtain utility billing data for use in re-allocation of demands (electronic format is expected with service addresses and customer type)
1.1.2.9 Process utility billing data
1.1.2.10 Confirm system water loss using billing and pumpage data
1.1.2.11 Re-allocate demands within model, including water loss
1.1.2.12 Confirm closed system valves
1.1.2.13 Review Filter plant and pump station operations
1.1.2.14 Obtain flow data for Filter plant and pump stations to verify demand usage and peaking patterns (electronic format, 15- minute or hourly data)
1.1.2.15 Obtain historical SCADA data to verify model replicates system operations, data needed includes plant, pump station and system pressures; tank levels and booster pump run times (electronic format, hourly data)
1.1.2.16 Perform model field verification, which shall not exceed 60 hours of LAN's time
1.1.2.17 Document model update process and verification results
1.1.2.18 Identify water lines to be flushed
1.1.2.19 Perform model analyses to determine flushing requirements
1.1.2.20 Identify discharge locations to be used during flushing
1.1.2.21 Prepare system maps
1.1.2.22 Outline flushing process / program
1.1.2.23 Assist the City in executing flushing program

1.1.3 Project Engineering Services to assist the City with monitoring and coordinating activities with city staff, MDEQ and vendors during the maintenance and implementation of improvements needed thru the August TTHM Sampling period. Services will be provided based on 60 hours/month for a total of five (5) months period
1.1.3.1 Provide a project engineer to work with City staff on an average of 15 hours/week or 60 hours/month for a total of 300 hours.

1.1.3.2 Coordinate between City staff, vendors, contractors and design professionals to insure timely implementation of design improvements needed to address TTHM issues.

1.1.3.3 Work at the City Water Treatment Plant if the City desires.

1.1.3.4 Develop an implementation schedule to help the City secure contractors and vendors to supply needed improvements to address TTHM recommendations in the next 5 months.

1.2 CMA Services.

1.2.1 Choosing Contractor. Engineer shall coordinate with Owner to select a Contractor to provide all construction related services for the Project at a lump sum fee and within schedule as agreed to by Owner.

1.2.2 Engaging Contractor on Behalf of Owner. As an agent for Owner, Engineer shall negotiate a mutually acceptable contract between Engineer (as agent of Owner) and Contractor ("Construction Contract"). Due to the urgent need for the Project to proceed expeditiously, Owner acknowledges and agrees the Owner shall be solely responsible for any and all risks associated with the Construction Contract except to the extent arising from liability, losses, claims, or expenses caused by Engineer's negligence or willful misconduct, and subject to the limitations provided under this Amendment. It is expressly understood that all benefits under the Construction Contract shall benefit the Owner including, without limitation, Contractor's insurance and bonding requirements, and any guarantees or warranties from the Contractor or Contractor's subcontractor(s). For the purpose of clarity, Engineer shall not be responsible for obtaining or securing any bonds or construction related insurance. Engineer, in coordination with and for the benefit of the Owner, shall negotiate the terms and conditions of the Construction Contract, which shall include a scope of services and schedule that is acceptable to Owner.

1.2.3 Engineer's Duties and Liabilities for CMA services As the Owner's agent, Engineer shall:

1.2.3.1 Act in the best interests of the Owner;

1.2.3.2 Have the authority, on behalf of the Owner, to enter into the Construction Contract, amend the Construction Contract (upon receiving written approval from the Owner) including any changes in the scope of work, schedule or fee.

1.2.3.3 Meet regularly with and oversee the Contractor as the Contractor provides its scope of services. Keep the Owner informed of any changes in the existing conditions, any discovery of unforeseeable conditions, and/or other circumstances that may materially impact the Contractor's scope of work.

1.2.3.4 Meet regularly with and oversee the Contractor's schedule and keep the Owner informed of any delays in the Contractor's schedule.

1.2.3.5 If required, seek adjustments in the Contractor's fee for delays caused by Contractor.

1.2.3.6 If required, seek adjustment in the Contractor's fee for Contractor's failure to comply with the Project's design and specifications.

1.2.3.7 Direct Contractor, on Owner's behalf, as needed to complete the Project consistent with the Project's design and specifications and the Contractor's schedule.

1.2.3.8 Obtain evidence that Contract has secured the appropriate bonds and insurance required under the Construction Contract.

1.2.3.9 Review and approve, on behalf of Owner, any and all payment requests submitted by Contractor and/or Contractor's subcontractors under the Construction Contract. Obtain all conditional and final lien and claim waivers as required under the Construction Contract.

1.2.3.10 Notwithstanding anything under this Agreement, and to the extent allowable under applicable law, Owner acknowledges and agrees Engineer's liability to any party under the Construction Contract shall be limited to the extent Engineer is an agent of Owner.

1.2.4 Owner's Duties and Liability. Owner shall:

1.2.4.1 Timely respond and provide Engineer clear and concise direction upon receiving any requests from Engineer.

1.2.4.2 Timely pay any and all invoices or other costs approved by Engineer, as Owner's agent, under the Construction Contract.

1.2.4.3 Execute any document or instrument reasonably needed to complete the Project on time and within budget.

1.2.4.4 To the extent allowable under law and to the extent not caused by Engineer's gross negligence or willful misconduct, indemnify, defend and hold Engineer harmless from any claims, costs, damages and/or expenses (including reasonable attorneys' fees) arising from Owner's failure to perform its obligations hereunder or under the Construction Contract.

2.0 ADDITIONAL TERMS AND CONDITIONS. The following terms and conditions shall apply to the services provided under this Amendment. In the event there are any conflicts with any of the terms of the contract document and the terms of this Amendment, the terms of this Amendment, in all instances, shall control and prevail. It is acknowledged and agreed that any term directly or indirectly related to indemnification, liability, warranty, or any other term within the contract document and provided below is superseded and replaced by the respective term provided below.

2.1 **Engineer Shall be Agent and Construction Manager not at Risk for Owner.** On behalf of the Owner, as an agent of the Owner, Engineer shall manage the contractor's work to construct the Project consistent with the additional Services described in Section 1.0 above. Owner hereby authorizes Engineer to act on behalf of the Owner and

Engineer shall act, consistent with the standard of care described in Section 2.2 below, in the best interests of the Owner. Notwithstanding anything hereunder, except for Engineer's breach of its standard of care or Engineer's willful misconduct or gross negligence, Owner acknowledges and agrees that:

2.1.1 Engineer shall not be responsible for the means, methods, techniques, sequences, or procedures of construction of the Project (the "Construction") selected or used by any contractor, or the safety precautions and programs incident thereto, for security or safety at the Project site, or for any failure of a contractor to comply with laws and regulations applicable to such contractor's furnishing and performing its work.

2.1.2 Owner shall release Engineer from any and all claims, costs, damages and/or expenses (including reasonable attorneys' fees) arising from or related to the Construction by any contractor or subcontractor;

2.1.3 To the extent allowable under law, Owner shall indemnify and defend Engineer from any and all claims, costs, damages and/or expenses (including reasonable attorneys' fees) arising from Owner's breach, default, or Owner's alleged breach or default of the Construction Contract including, but not limited, Owner's failure to timely pay any sums due any contractor or subcontractor providing Construction services.

2.2 **Standard of Care and Disclaimer of Warranty.** The standard of care for all professional Engineering and related services performed or furnished by Engineer under this Amendment will be the care and skill ordinarily used by members of the Engineering profession practicing under similar circumstances at the same time and in the same locality. Engineer makes no warranties, express or implied, under this Amendment or otherwise, in connection with Engineer's services. Engineer and its consultants may use or rely upon design elements and information supplied by Owner which are ordinarily or customarily furnished by others, including, but not limited to, specialty contractors, manufacturers, suppliers, and the publishers of technical standards.

2.3 **Indemnity by Engineer.** Engineer shall indemnify and hold harmless the Owner from and against losses, costs, and damages caused solely by the negligent acts, errors or omissions of Engineer, its officers, directors, partners, employees and Consultants in the performance of professional services under this Amendment.

2.4 **Limitation of Liability.** To the fullest extent permitted by law, Owner and Engineer (1) waive against each other, and the other's employees, officers, directors, agents, insurers, partners, and consultants, any and all claims for or entitlement to special, incidental, indirect, or consequential damages arising out of, resulting from, or in any way related to the Project, and (2) agree that Engineer's total liability to Owner under this Agreement, based upon Comparative Negligence principles, shall be limited to $300,000.

2.5 **Hazardous Material.** Owner and Engineer acknowledge that Engineer's scope of services under this Amendment does not include any services related to a Hazardous Environmental Condition (the presence of asbestos, PCBs, petroleum, hazardous substances or waste as defined by the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. §§9601 et seq., or radioactive materials). If Engineer or any other party encounters a Hazardous Environmental Condition, Engineer may, at its option and without liability for consequential or any other damages, suspend performance of services on the portion of the Site or Project affected thereby until Owner: (1) retains appropriate specialist consultants or contractors to identify and, as appropriate, abate, remediate, or remove the Hazardous Environmental Condition; and (2) warrants that the Site or Project is in full compliance with applicable Laws and Regulations.

2.6 **Force Majeure.** Engineer shall not be responsible for and Owner hereby releases Engineer from any claim, damage or loss resulting from (i) fires, riots, labor disputes, war, terrorism, weather, acts of GOD, or other Force Majeure; (ii) governmental action or failure to act (including, without limitation, plan reviews, permits, and or approvals); (iii) unforeseeable circumstances or conditions (including, without limitation, unforeseeable site conditions); and (iv) circumstances or events outside the reasonable control or responsibility of Consultant.

3.0 CHANGES TO CONTRACT PRICE

APPROVED:

AS TO FORM:

Peter M. Bade
City Attorney

ACCEPTED:

FIRM: **LOCKWOOD, ANDREWS & NEWNAM**

BY: ____________________

TITLE: ____________________

ADDRESS: ____________________

THE CITY OF FLINT,
A MUNICIPAL CORPORATION

BY: ____________________
Natasha L. Henderson, City Administrator

BY: ____________________
Dayne Walling, Mayor

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

Client Additional Services Authorization

Date: 10-4-15

Project Name	Additional Services Authorization No.
Flint WTP Phase II Segment I Initial Watermain Cut-in Flint WTP Phase II Segment I Rehab Flint WTP Ph II-Seg II - Lime Residual Disposal Flint Distribution System Modeling/Water Age Analysis	
Client Name City of Flint	**To Project No.** 130-10701-001
Subject of Additional Services	**Original Contract Date** 6-26-2013

Description

Provide additional services as indicated below and detailed in the attached document for the four (4) projects listed above as noted:

1- Flint Distribution System Water Age Analysis, Calibration and Flow Control Scenarios; ($74,700.00)
2- 42" Raw Water Line to PS4 associated with KWA Service; ($18,950)
3- Filter Transfer Station Design and Construction Implementation in preparation of KWA Connection; ($540,000.00)
4- Lead and Corrosion Analysis, Design and Implementation to address MDEQ Notice; ($36,400)
5- Standard Operating Procedures/Checkoff lists Development for main processes and equipments at the plant; ($21,600)
6- Design Assistance & Technical Support until KWA System is in Place @ $10,000/month for 18 months; ($180,000.00)
7- Jar Testing associated with Lake Huron Water as a source in preparation of KWA switch; ($36,000)

Reason for Change

1) Coordination and Calibration of water System Performance and Operational Changes and Storage System Modifications to determine Water Age Analysis in the distribution system associated with the TTHM Issues and Chlorine Residual in the system.
2) Provide design changes to assemble a bidding package for the 42" Raw Water line connection to PS4 for KWA
3) Develop design and Bid Package for the Filter Transfer Station in preparation of KWA Connection and Manage construction activities on behalf of the City with the selected contractors.
4) Evaluate, Design and Implement Improvements associated with addressing the Lead and Corrosion Issues and respond to MDEQ Concerns.
5) Compile Standard Operating Procedures and Checkoff lists for equipments and processes used by the City working with City staff and vendors and reviewing available O&M Manuals
6) Design Assistance & Technical Support to address treatment issues and operational controls until KWA Changes.
7) Conduct Jar Testing on Lake Huron Water in anticipation of KWA switch in the summer of 2016 in order to assess operational needs and process changes at the Plant.

Compensation:

☐ Will be an amount equal to _____ times Salary Cost plus reimbursable expenses, both defined in the **PROFESSIONAL SERVICES AGREEMENT**, and in addition to the compensation for **BASIC SERVICES**. Total charges for these **ADDITIONAL SERVICES** are estimated to be approximately $_____.

☐ Will be the lump sum of $_____ for these **ADDITIONAL SERVICES**.

☒ Other __Cost plus based on current rates for a Total amount of $907,650.00__ (use reverse if necessary)

150929

SUBMISSION NO.: CA114 2015

PRESENTED: 11-12-15

ADOPTED: RTAB 12-9-15

RESOLUTION

BY THE CITY ADMINISTRATOR:

Resolution Authorizing Change Order #5 to the Lockwood, Andrews & Newnam Contract for the Implementation of Water Plant Operations

The City of Flint Department of Public Works & Utilities (DPW & Utilities) entered into a contract with Lockwood, Andrews, and Newnam to study the feasibility and develop cost estimates for the Water Plant as a primary water source in a contact amount not to exceed $1,378,700.00; and

The City of Flint DPW & Utilities entered into change order #4 for additional services to provide a turn-key system of new GAC media in the twelve (12) filters at the Flint Water Plant in an amount not to exceed $1,601,740.000 for a revised total contract amount of $2,980,440.00. Additional services are required to evaluate, design and implement improvements associated with the MDEQ concerns addressing the lead and corrosion issues and design and construction in preparation of the KWA connection. The total cost of additional services is not to exceed $907,650.00 for a revised total contract amount of $3,888,090.00. Funding for said services will come from account 591-536.100-801.000; and

IT RESOLVED, Appropriate City Officials are to do all things necessary to enter into change order #5 in an amount not to exceed 907,650.00 for a total revised contract price of $3,888,090.00. Funding will come from account 591-536.100-801.000.

APPROVED AS TO FORM:

Peter M. Bade, Chief Legal Officer

Natasha L. Henderson, City Administrator

APPROVED AS TO FINANCE:

Jody N. Lundquist, Finance Director

CITY COUNCIL:

Kerry Nelson, Council President

PRESENTED TO CITY COUNCIL: 11/18/2015
ADOPTED BY CITY COUNCIL: 11/23/2015

RECEIVERSHIP TRANSITION ADVISORY BOARD:

ADOPTED BY THE RECEIVERSHIP TRANSITION ADVISORY BOARD DECEMBER 9, 2015

EXHIBIT D

CITY OF FLINT

Department of Public Works

Dayne Walling Mayor	Gerald Ambrose Emergency Manager	Howard Croft Director

TO: City of Flint Residents

RE: **Water Questions**

DATE: January 13, 2015

Prelude

The decision to switch to the Karegnondi Water Authority as the City's permanent water source was made following extensive research and in-depth engineering studies. After entering into a contract with KWA and the subsequent termination of the existing water service contract by the Detroit Water and Sewerage Department, the same diligence was given in determining what source water to use while waiting for the community supported KWA water to arrive. The City concluded from this work that the Flint River presented a safe and financially responsible alternative water source. The decision to use the Flint River as an intermediate water source was approved by state regulatory officials in 2014 whereby the City was permitted by the Michigan Department of Environmental Quality to proceed with treatment of water from the Flint River.

The following questions were presented by concerned citizens, and the City's responses follow. This document will be put on the City's website for public viewing within the next several days.

1. What was the process by which the decision was made to switch from Detroit water to Flint River water? Who was responsible for what decisions?

On March 25th, 2013, after evaluating **cost comparisons** for a permanent water source, the Flint City Council, with support from the Mayor, voted 7 – 1 approving a resolution to purchase water from the Karegnondi Water Authority (KWA). On March 29th, resolution 2013EM041 was signed, authorizing the City of Flint to enter into a contract with the KWA.

On April 16th, 2013, then Emergency Manager Ed Kurtz, signed the contract effectively purchasing 18 MGD of capacity from the KWA.

On April 17th, 2013 Detroit Water and Sewerage Department (DWSD) sent a letter terminating the existing water service contract between the City of Flint and Detroit. With the termination set to take effect 12 months later on April 17th, 2014, a gap was created between the end of the DWSD contract and the start of the KWA.

On June 29th, 2013, following many preliminary discussions on how the City would fill the interim gap, a formal, all day meeting was held at the Flint Water Plant with all interested parties including City of Flint Officials (COF), representatives from the Genesee County Drain Commissioners Office (GCDC), the Michigan Department of Environmental Quality (DEQ), and the design engineers from the previous plant upgrade Lockwood, Andrews, and Newnam (LAN).

The purpose and agenda of the meeting was to determine the feasibility of the following items:

1. Using the Flint River as a Water Source
2. The ability to perform the necessary upgrades to the Treatment Plant
3. The ability to perform quality control
4. *The ability for Flint to provide water to Genesee County*
5. The ability to meet an April/May 2014 timeline
6. Development of a cost analysis

The conversation was guided with focus on the engineering, regulatory, and quality aspects of each item listed. The resulting determinations were made.

1. Yes, the Flint River would be more difficult to treat but is viable as a source.
2. Yes, it was possible to engineer and construct the upgrades needed for the treatment process.
3. Yes, with support from LAN engineering which works with several water systems around the state, quality control could be addressed.
4. No, the Flint treatment plant would not have the capacity needed to treat and distribute sufficient water to meet the documented needs of Flint and Genesee County.
5. Possible, it was determined that many obstacles needed to be overcome but completion by the April/May 2014 target was reachable.
6. Next steps from the meeting were for LAN to present the City with a proposal that would include engineering, procurement, and construction needs for the project along with cost estimates.

As a result of extensive evaluation, discussions with the professional engineers, and consulting the state regulators, the Department of Public Works along with the Finance Department recommended utilizing the Flint River as a temporary water source while waiting for the KWA to come online. The plan to accomplish this was accompanied with a construction timeline, a needs analysis for resources, and an FY 14 spending plan to complete the project.

2. Was it known prior to the switch that there would be problems managing total coliform and fecal coliform bacteria levels in the water?

It was understood that the Flint River would be subject to temperature variations, rain events, and have higher organic carbon than Lake Huron water and would be more difficult to treat. These facts were balanced against a licensed staff, LAN engineering's extensive experience in this field, advanced equipment that Flint has for treatment, and support from the DEQ.

3. What were the projected costs and benefits of the switch, and what have been the actual costs and benefits?

The engineered costs for upgrading the Flint Plant to treat KWA water from Lake Huron were projected to be ~$9,000,000. These upgrades need to be in place prior to KWA water reaching Flint and are coupled with an additional ~$3,500,000 in annual operational expenses for workforce additions, electricity costs, and process equipment for a total of ~$12,500,000

The final year that the City of Flint purchased water from DWSD, the cost was $12,400,000 and that cost was projected to rise to ~$14,400,000 in 2014 and increase to ~$16,000,000 in 2015.

The financial benefit for switching to the river was the opportunity to divert that revenue towards capitalizing the upgrade expenditures needed to run the plant and the development of a capital improvement program for the aged infrastructure without a significant increase to the water bill. This aspect was figured into the cost analysis at the time of the recommendation.

Based on the current DWSD rate structure, it appears that the actual costs to purchase water this year would have been higher than projected, The fixed cost would have been ~$5,100,000 and the additional commodity or water costs would have resulted in another ~$11,000,000 given the City's current water usage. This would result in an estimated ~$16,000,000 in this year alone.

The upgrade expenditures stayed close to the engineered projections The improvements at the water plant cost ~$7,000,000, the remediation and development of Bray Rd for lime disposal cost ~$1,700,000 and the increased operational costs so far this year are below the estimates and on target to finish the year at ~$3,000,000. These changes come to a total of ~$11,700,000 of necessary expenditures in the first year.

In addition to the ability to capitalize the upgrades, switching to the Flint River has allowed us to develop a Capital Improvement Plan for the Utility Department that will begin replacing pipe underground this spring and will account for overdue maintenance concerns such as valve replacements, and pipe lining extending the useful life of the system and allowing us to deliver better quality water.

It would have required close to a 30% raise in the water and sewer bill to accomplish this without using the Flint River as a source.

4. What were the causes of increased levels of trihalomethanes? Have those causes been sufficiently addressed? If not, what needs to be done to prevent this from occurring again in the future?

Just as low levels of chlorine can produce coliforms, high levels of chlorine can result in Disinfectant Byproducts (DBP) generating increased levels of trihalomethanes (TTHM). The DEQ requires this testing to occur once every three months at each of the testing sites and looks at an average over four quarters (one year) to determine the level to compare against the maximum contaminant level (MCL).

Research by the Science Advisory Board, the National Academy of Sciences, and the USEPA's Carcinogen Assessment Group predicts **risk estimates** associated with high levels of TTHM at an incremental risk of 3 to 4 people out of 10,000 that consume 2 liters of water over the MCL daily for 70 years.

The required remedy for this violation is to present the DEQ with an **Operational Evaluation Report** that assesses what caused the violation and what the proposed remedy is. The City generated a report to the DEQ in November 2014, which assesses each area of the Flint water system including water source, treatment process, and distribution system. The evaluation was complete with short and long term recommendations to optimize each area and the belief that the items listed would correct the violation and give Flint an increased ability to manage the system. Continued repairs on valves and colder temperatures have created a more consistent chemical footprint, and we have been producing a more consistent water quality.

5. What were the causes of increased levels of total coliform and fecal coliform bacteria levels? Have those causes been sufficiently addressed? If not, what needs to be done to prevent this from occurring in the future?

What we discovered is that as water travels through the 600 miles of the City's distribution mains it will, at times, reside in the system for up to 3 or 4 weeks. Water purchased from DWSD is drawn from Lake Huron, chlorinated, and then travels over 80 miles to reach the City. By the time the water reaches Flint it is stable and capable of withstanding this type of residency time within the system. Water drawn from the Flint River, specifically in summer months when the temperature is fluctuating, is more susceptible to being impacted by variables such as high residency times and increased chemical reaction.

The DEQ requires that a minimum of 100 tests be performed monthly for chlorine residuals at various locations throughout the system. When residual levels are too low, it creates an environment in which bacteria such as fecal coliform can grow. After switching sources, we encountered testing sites in June, 2014 that were consistently returning low residual levels. Several of these sites became areas that total coliform was eventually detected and ultimately boil water notices issued.

Low residual levels can sometimes trigger a positive test result for total coliform which is an indicator of a poor water environment but does not generally require a boil water notice. The normal course of action in these situations is to flush hydrants and introduce fresh water into the defined area. In certain areas this was successful and in other areas it was not. In a second course of action, the EPA also allows for water systems to increase the residual disinfectant, including chlorine, to a level and for a time necessary to protect public health. This information can be found in the EPA manual **(40 CFR 141.65 & 141.130(d))**. In contending with the low residual levels which represent a more immediate health concern along with the potential for tier 1 violations and boil water notices, we increased the chlorination treatment at times in order to combat the low residuals. This was also was an unsuccessful remedy and only after we located and replaced valves that were broken in the closed position on major transmission lines in these areas did the residual levels return to normal and have remained that way since.

There is still one test site, in the 2500 block of Flushing Rd. where we continue to experience low residual levels and we are actively pursuing efforts to locate more expected valve failures. The development of a hydraulic model of the system and the ability to use unidirectional flushing are tools that will assist us in mitigating areas where low residuals surface. Both of these are in progress of being developed by the engineering firm LAN and Potter Consulting who was also the author of our Water Reliability Study.

6. What are the public reporting requirements for these sorts of problems, and has the City met those requirements? What can be done to communicate in a more timely manner useful information about a public health threat such as the presence of cancer-causing chemicals in our drinking water?

The **EPA 2010 "Revised Public Notification Handbook"** has a specific breakdown of the elements required in public notifications and includes usable templates. The EPA has three different tiers associated with community water systems (CWS), each with specific timeframes and requirements that trigger upon issuance of the violation.

- Tier 1. CWS must provide public notification within 24 hours of a violation and continue this as directed by the primary agency.
- Tier 2. CWS must provide public notification within 30 days of a violation and continue this every three months until the violation is resolved
- Tier 3. CWS must provide public notification within one year and the EPA recommends repeat occurrences be provided in an annual notice

The **current EPA violation** is classified as a tier 2 violation and was issued December 16th, 2014.

Moving forward, the City of Flint is striving to increase communication with the public in a variety of ways.

- The city's new website will have current news and information updated on a regular basis.
- Increased data collection will be transitioned into real time ability to communicate with the residents through the Public Works area of the City's new website.
- Timely reporting of current test results on the new City website.

The establishment of these tools is in progress and expected to be implemented in the near future along with evaluating other avenues of communication.

7. Is there any reason to think that these or similar problems will continue even after the shift is made to water from Lake Huron?

The water coming from Lake Huron via KWA will be more consistent in temperature, have lower organic carbon, and will be less susceptible to variations but will have its own chemical footprint. The construction upgrades to the Flint Treatment Plant give us the ability to draw water from either source and should provide Flint the opportunity for testing and thereby streamlining the treatment process to match the Lake Huron chemical footprint before fully introducing it into the distribution system.

In addition to new source water, following the recommendations contained in the Operational Evaluation Report and the City's **Water Reliability Study** is the roadmap to being able to provide quality water.

Continuing to identify integrity issues and making preemptive repairs within our antiquated infrastructure are needed to maintain and provide a healthy system. Leak detection which is scheduled for the spring, hydraulic system modeling which includes unidirectional flushing is in progress now and will give us the information and tools to accomplish these goals.

8. Who is responsible for making sure we don't have these sorts of problems, and did that person or those people fail to meet their responsibilities?

The Utility Department is a Division underneath the Department of Public Works. The Public Works Director along with the Utilities Administrator will continue to work hand in hand with professional engineers, consultants, and the state regulatory agency DEQ in order to manage increased public communication and address any issues that arise going forward.

The DEQ requires that public water systems with population over 20,000 must have an F-1 state licensed operator in charge that oversees the operation of the treatment process. This license is the highest classification in the state that specializes in "complete treatment" The City of Flint has such a person on staff at the water plant and that person's responsibility is to determine the correct levels of chemical treatment, monitor the system, submit official test results to the state regulatory agency, and make necessary adjustments when contaminant levels are breached. All of these steps were followed and acknowledged by the DEQ.

The following is the list of supporting documents that will be available on the City's website for public viewing.

Cost Comparisons (the ROWE Study)

Upgrade Construction Timeline

EPA Chlorinating Information

Risk Assessment Information

Operational Evaluation Report

EPA 2010 revised Public Notification Handbook

The Current DEQ Violation Letter

Flint Water Reliability Study

Respectfully submitted,

Howard D Croft
Public Works Director

Dayne Walling
Mayor, City of Flint

Gerald Ambrose
Emergency Manager

EXHIBIT E

EM SUBMISSION NO.: 2013 EM140

PRESENTED: 6-21-13

ADOPTED: 6-26-13

BY THE EMERGENCY MANAGER:

Resolution Authorizing Approval to Enter into a Professional Engineering Services Contract for the Implementation of Placing the Flint Water Plant into Operation

The City of Flint requires professional engineering services for assistance in placing the Flint Water Plant into operation using the Flint River as a primary drinking water source for approximately two years and then converting to KWA delivered lake water when available at a cost of $171,000.00; and

The City of Flint is seeking to enter into a sole source contract with Lockwood, Andrews & Newnam, Inc., with funding coming from the Utilities Administration FY14 account in 591-536.100-801.000; and

IT RESOLVED, That appropriate City Officials are authorized to enter into a Professional Engineering Services contract with Lockwood, Andrews & Newnam, Inc., for the administration of placing the Flint Water Plant into operation using the Flint River as a primary drinking water source at a cost of $171,000.00. Funding will come from the Utilities Administration FY14 account 591-536.100-801.000

APPROVED AS TO FORM:

for

Peter M. Bade, Chief Legal Officer

APPROVED AS TO FINANCE:

Jerry Ambrose, Finance Director

EM DISPOSITION:

ENACT ✓ **FAIL** ______ **DATED** 6-26-13

Edward J. Kurtz, Emergency Manager

RESOLUTION STAFF REVIEW

Date: June 17, 2013

Agenda Item Title: Resolution Authorizing Approval to Enter into a Professional Engineering Services Contract for the implementation of Placing the Flint Water Plant into Operation

Prepared by:
Yolanda Gray, Utilities Accounting Coordinator

Summary of Proposed Action:
Resolution authorizing the City of Flint to enter into a sole source contract with Lockwood, Andrews & Newnam for professional engineering services to place the Flint Water Plant into operation using the Flint River as a primary drinking water source.

Financial Implications:
$171,000.00

Pre-encumbered?: Yes____ No __x____ Requisition: Funding will be available in the FY14 Utilities Administration budget.

Account No. FY14 591-536.100-801.000

Other implications (i.e. collective bargaining):
No other implications are known at this time.

Staff Recommendation: Recommend Approval

Staff Person ______________________
Howard Croft
Infrastructure & Development Director

____
Daugherty A. Johnson III
Utilities Administrator

EXHIBIT F

Proposed Scope of Upgrades to Flint WTP

Phase II - Segments I & II

1. Introduction

The City of Flint plans to utilize their existing WTP to provide water on a continuous basis. The city plans to treat water from the Flint River until construction of the proposed KWA supply is complete and the WTP can then be used to treat water from Lake Huron. The following proposed improvements are needed to place the WTP into service next spring. These improvements will remain in service once the KWA is in service.

2. Scope of Work

The proposed upgrades have been categorized into Phase II – Segment I and are to be completed as soon as practical so that the WTP can be utilized to treat water from the river in the spring of 2014. Engineering services will include final design, plans, contract documents, bidding assistance. Since time is of importance, specifications and schematic drawings will also be provided for pre-procurement of long lead item equipment and are outlined within each section below. Contract administration and construction phase services are not included within the initial scope of services.

- Design Progress Meetings: Meet with City staff to provide project status updates and to discuss specific design issues and details in order to facilitate timely design decisions. Meetings will include design team personnel from each discipline as required, City operations staff and administrative staff. Five (5) design progress meetings are included.
- Prepare and update opinion of probable construction cost at for each project bidding document submittal (40%, 80% and Final Draft). Prepare final opinion of probable construction cost prior to bidding.
- Quality Assurance/Quality Control: A Quality Control Plan (QCP) will be developed and implemented specifically for this project. At each project submittal stage, the document deliverables will be checked and reviewed by experienced personnel to ensure that the design meets applicable standards and normal engineering practice.
- Deliverables:
  40% Bidding Documents (Drawings and Technical Specification Outline)
  80% Bidding Documents (Drawings and Technical Specifications)
  Final Draft Bidding Documents (Drawings and Technical Specifications)
  Final Bidding Documents (One printed and one electronic set of Drawings and Technical Specifications
- Bidding Phase
  Conduct pre-bid meeting.
  Respond to contractor inquiries.
  Prepare construction document addenda, as necessary.

Review bids and supporting bid documentation. Prepare bid report summarizing bids, contractor references, and contractor qualifications; make recommendation for contract award.

- Construction Phase

  Review and respond to contractor submittals (First two reviews are included in level of effort, subsequent review cost will be paid for by contractor)

  Respond to contractor's request for information

  Prepare monthly payment documents

  Negotiate and prepare change orders for client review and approval

  Attend monthly project meetings

  Provide periodic onsite technical observer (have included two weeks per month in level of effort)

  Develop record documents (provide one hard and one electronic copy to owner)

Specific Work Tasks:

Prf

Item 1 – Chemical Systems / Ozone

The Michigan Department of Environmental Quality (MDEQ) requires 30 days of redundant storage of the chemical used in this treatment process. To bring the rehabilitated plant into regulatory compliance with the chemical storage requirements for primary use, additional storage facilities will need to be constructed for liquid oxygen and nitrogen.

One liquid oxygen and one liquid nitrogen storage tanks and unloading stations identical to the existing units will be installed north of the existing facilities. Details are listed as follows:

Liquid Oxygen	Liquid Nitrogen
Capacity – 9000 gallons	Capacity – 540 gallons
Diameter – 10 ft (maximum)	Diameter –5.5 ft (maximum)

Pre-procurement documents for the liquid oxygen and nitrogen tanks will be provided.

Item 2 – Electrical

The City of Flint Water Treatment Plant (WTP) represents a combination of administrative, process, and maintenance facilities which all require electrical power. At the completion of Phase I of the water treatment plant rehabilitation projects, much of the electrical distribution equipment such as motor control centers (MCCs), power/lighting panels, transformers, and electrical power feeders will have been upgraded. There is, however, significant additional work required to address remaining electrical equipment that has reached a point of obsolescence.

Switchgear in the sub-station was installed around 1960. It is antiquated and difficult to maintain. Very little work has been done to the station since its original installation. The plant has two 46 kV primary feeds into the sub-station. Replacement of the distribution switchgear with current technology

equipment would allow a higher degree of load protection, be serviceable by numerous sources, and have replacement parts availability. When the switchgear is replaced, the plant will have to stay in operation. Brief interruptions of power of selected plant processes could be accommodated during cut over to new equipment.

Proposed Substation Upgrade

- Coordinate upgrades to Consumers 46kV primary feeders to provide a single overhead 46KV primary service
- Replace the two Consumers 2.5kVA substation transformers and overhead structure with two 2.0 to 2.5 kVA 46KV pad-mounted transformers.
- Replace the City's substation switchgear in the substation building.

Pre-procurement documents for the pad mounted transformers and switchgear will be provided.

Pump Station No.4 contains the largest electrical loads in the plant. Four low service pumps and five high service pumps represent a combined total of approximately 4000 horsepower. Additional loads from HVAC, lighting, controls, and chemical feed are about 60 kVA. This represents a total load of 531 amps @ 2400 volts. The existing switchgear in Pump Station No.4 is antiquated and difficult to maintain. Current technology equipment will allow a higher degree of load protection.

Proposed Pump Station No. 4 Improvements

- Replace 2400V switchgear
- Provide one 15 MGD medium voltage VFD

Pre-procurement documents for the medium voltage VFD and switchgear will be provided.

As a base load facility capable of producing water at any time the Flint WTP must have the ability to deal with power outages. In order to meet these electrical need in the event of a loss of power to the plant site or the loss of one of the substation transformers a new standby diesel generator is proposed to be located adjacent to the new substation.

Proposed Standby Power Improvements

- One 2.0 to 2.5 mVA generators and fuel tank. – Provisions, But no actual generator

Pre-procurement documents for the generator set will be provided.

There are four 2400V to 480V transformers in Plant 2 that are antiquated and difficult to maintain. Replacement parts are no longer available and reliability is questionable.

Proposed Plant 2 Improvements

- Replace two 300kVA 2.4KV transformer/switchgear.
- Replace two 100kVA 2.4KV transformer/switchgear.

Pre-procurement documents for the transformers and switchgear will be provided.

Item 3 – Mid-Point Chlorination

Mid-point chlorination facilities are proposed to increase reliability of the disinfection process and improve Ct. For this initial stage the existing chlorine equipment in Pump Station No. 4 will be used and a new chlorine solution line will be installed from Pump Station No. 4 to the filter influent channel in Plant 2. A chlorine scrubber system will be installed in Pump Station No.4 to protect against a leaking chlorine ton container.

Proposed Chlorine Improvements

- New chlorine solution line to filter gallery.
- Chlorine system improvements.
- Dry scrubber system.

Item 4 – Low and High Service Pump Station No. 4

As a result of decreased demands, pumps at Pump Station No. 4 are "over-sized" and do not efficiently operate. Some of the pumps experience vibrations in the shafts and steady bearings. The existing pump station will be rehabilitated to replace "over-sized" pumps and obsolete equipment and provide needed maintenance.

Proposed Pump Station No. 4 Improvements

- Install one new High Service Pump (15 MGD @190 feet TH, vertically mounted pumps with 800 HP 2400/4160 V inverter duty motors, with 20 feet of shaft and steady bearings)
- Replacement of existing piping, valves, supports, and bearings
- New intermediate platforms, ladders, & stairs
- New ventilation (for exhausting heat from VFD's)
- Demolition of existing equipment to accommodate new equipment

Pre-procurement documents for the pump, motor, control valves and isolation valves will be provided.

Item 5 – Raw Water Piping Connection

The proposed KWA raw water pipeline will connect to the existing 72" PCCP finished water supply line near Center and Pierson Roads. (East of this connection, the 72" PCCP will be utilized by GCDC-WWS for distribution of finished water in the GCDC-WWS service area.) Raw water from Lake Huron will be conveyed to the WTP site via the 72" PCCP pipeline. On the WTP site, the 72" pipeline will be tapped for a 42" pipe and for a 36" pipe to convey raw water for treatment. Connections to the existing pipe will be made at this time to avoid future plant shutdowns for connections.

Proposed Pump Station No. 4 Improvements

- 48-inch pipe connections
- 36-inch pipe connection
- 54-inch pipe connection

Pre-procurement documents for the valves and connection fittings will be provided.

Phase II – Segment II:

The proposed upgrade for item 6 has been categorized as Phase II – Segment II and is to be completed with the same urgency as the rest of the work so that the WTP can be utilized to treat water from the river in the spring of 2014. However, the use of the Bray Road lagoon for other disposal activities will require that this issue be addressed independently to certain extent as to isolate the problem areas while working with MDEQ to permit its use for lime sludge disposal.

Item 6 – Softening Residuals Disposal

Develop, evaluate, design and implement a lime residuals disposal plan to handle softening sludge for the interim period of operation using the Flint River as a water source. These options may include the use of Bray Road lagoon, construction of temporary dewatering and loading facilities, and other temporary storage options.

The use of Bray Road Lagoon will require additional survey, geotechnical and environmental testing at the site in order to assess the condition of the lime sludge in the basin and to verify the capacity of the lagoon system. Based on the findings of this evaluation, proposed improvements will be designed to accommodate the use of the facility in the interim basis while addressing some of the MDEQ concerns about the site and any unauthorized discharges into the nearby stream. Permitting for site use will be incorporated as part of the overall design improvements at the WTP and submitted to the MDEQ at the 80% design stage for their pre-permit review and comments. A final package will be submitted to the MDEQ at the 100% design stage for permit issuance and approval of work plan.

Pre-procurement documents for specific equipment may be provided as needed.

3. Schedule

The work included in this work authorization is anticipated to be performed in accordance with the following schedule, based on the Notice-To-Proceed (NTP) date of November 1, 2013. For the purposes of this proposal, we anticipate a 3 month design phase and 1 month bid phase. Schedule revisions may be necessary as information becomes available and work priorities change.

Project Milestone	Date
Project Kickoff Meeting	November 6, 2013
Equipment Procurement Documents	December 6, 2013
Submit 40% Bidding Documents	December 18, 2013
Submit 80% Bidding Documents	January 10, 2014
Submit Final Draft Bidding Documents	January 31, 2013
Submit Final Bidding Documents	February 7, 2014
Bid Advertising	February 10, 2014
Pre-Bid Meeting	February 17, 2014
Bid Opening	TBD by City
Recommendation of Contract	TBD by City
Contract Award issued by City	TBD by City

4. Compensation

The Reimbursable Compensation method with a maximum not-to-exceed limit will be used for this contract. Labor rates shall be based on personnel classifications according to the existing rate sheet. Reimbursable expenses shall be invoiced at the actual cost times a factor of 1.0 for processing and handling. The estimated maximum not-to-exceed fee for this project is $962,800 which includes a $15,000 allowance for surveying and $15,000 allowance for geotechnical services.

Description	Fee
Design and Bidding Assistance	$ 752,800
Surveying Allowance	$ 15,000
Geotechnical Allowance	$ 15,000
Construction Phase Services	$ 180,000
Total Maximum Not to Exceed Fee	**$ 962,800**

Any other work beyond the Scope of Services herein will require a subsequent Work Authorization with prior approval from the City.

EXHIBIT G

2310

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

PERMIT APPLICATION FOR WATER SUPPLY SYSTEMS

(CONSTRUCTION - ALTERATION - ADDITION OR IMPROVEMENT) AS DESCRIBED HEREIN

Required under the Authority of 1976 PA 399, as amended

This application becomes an Act 399 Permit only when signed and issued by authorized Michigan Department of Environmental Quality (DEQ) Staff. See instructions below for completion of this application.

1. Municipality or Organization, Address and WSSN that will own or control the water facilities to be constructed. This permit is to be issued to: City of Flint 4500 North Dort Highway Flint, MI 48505 **WSSN:** 02310	Permit Stamp Area (DEQ use only) MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY PERMIT NO. W 140025 APR 09 2014 EXAMINED AND APPROVED FOR COMPLIANCE WITH ACT 399, P.A. 1976
2. Owner's Contact Person (provide name for questions): Contact: Brent Wright Title: Plant Supervisor Phone: 810-787-6537	

3. Project Name (Provide phase number if project is segmented): 1) Flint WTP Phase II, Sement I - Initial Watermain Cut-In / Rehabilitation; 2) Flint WTP Phase II, Segment II - Lime Residual Disposal; 3) Flint WTP Phase II, Segment III - Electrical Improvements	**4. Project Location** (City, Village, Township): City of Flint	**5. County** (location of project): Genesee County

ISSUED UNDER THE AUTHORITY OF THE DIRECTOR OF THE DEPARTMENT OF ENVIRONMENT QUALITY

cc:

Issued by: [signature]

Reviewed by: Patrick Cook for MPP for Mike Prysby

☐ **If this box is marked see attached special conditions.**

Instructions: Complete items 1 through 5 above and 6 through 21 on the following pages of this application. Print or type all information except for signatures. Mail completed application, plans and specifications, and any attachments to the DEQ District Office having jurisdiction in the area of the proposed construction.

Please Note:

a. This **PERMIT** only authorizes the construction, alteration, addition or improvement of the water system described herein and is issued solely under the authority of 1976 PA 399, as amended.
b. The issuance of this **PERMIT** does not authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other DEQ permits, or approvals from other units of government as may be required by law.
c. This **PERMIT** expires two (2) years after the date of issuance in accordance with R 325.11306, 1976 PA 399, administrative rules, unless construction has been initiated prior to expiration.
d. Noncompliance with the conditions of this permit and the requirements of the Act constitutes a violation of the Act.
e. Applicant must give notice to public utilities in accordance with 1974 PA 53, (MISS DIG), being Section 460.701 to 460.718 of the Michigan Compiled Laws, and comply with each of the requirements of that Act.
f. All earth changing activities must be conducted in accordance with the requirements of the Soil Erosion and Sedimentation Control Act, Part 91, 1994 PA 451, as amended.
g. All construction activity impacting wetlands must be conducted in accordance with the Wetland Protection Act, Part 303, 1994 PA 451, as amended.
h. Intentionally providing false information in this application constitutes fraud which is punishable by fine and/or imprisonment.
i. Where applicable for water withdrawals, the issuance of this permit indicates compliance with the requirements of Part 327 of Act 451, Great Lakes Preservation Act.

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

Permit Application for Water Systems (Continued)

6. **Facilities Description** – In the space below provide a detailed description of the proposed project. Applications without adequate facilities descriptions **will be returned**. SEE EXAMPLES BELOW. Use additional sheets if needed.

Improvements to the City of Flint WTP to enable treatment of Flint River water on an interim basis until the KWA Lake Huron Water Supply is available for connection and use by the City of Flint:

PHASE II, SEGMENT I - INITIAL WATERMAIN CUT-IN / REHABILITATION (@WTP):
* Replace existing 25 MGD HSP #1 at Pump Station No. 4 with a new 700 HP, vertically mounted, split-case centrifugal pump rated for 15 MGD at 185' TDH. New pump suction and discharge piping, valves and supports will also be provided.
* Construction of new ozone system LOX/LIN storage facility to provide system redundancy and a minimum of 30 days chemical storage. A new concrete containment structure will be constructed adjacent to the existing LOX/LIN storage facility. The new LOX and LIN tanks will have nominal capacities of 9000 gal. and 525 gal., respectively.
* Installation of Midpoint Chlorination. A 3"x6" dual walled chlorine solution line, approx. 665 LF, will be installed from the existing chlorine room at Pump Station No. 4 to a diffuser in the filter influent channel at Plant 2. The chlorine gas feed system shall consist of four 500 ppd feed systems (total 2000 ppd) to be installed by City personnel. Each 500 ppd system consists of a ton cylinder mounted vacuum regulator, control panel, ejector, and misc. piping, tubing & valves.
* Approx. 850 LF 42" raw watermain connection from existing 48" and 36" mains that feed the plant to convey KWA raw water to the Ozone Building. Work includes a 54x48 cross to make the initial connection at the Ozone Building, buried yard butterfly valves, access and air release manholes, and cathodic protection test stations.

PHASE II, SEGMENT III - ELECTRICAL IMPROVEMENTS (@WTP):
* Plant substation improvements, including two new 2500 kW transformers and switchgear. The substation switchgear has been fabricated with two utility main breakers, one generator breaker and two tie breakers. So provisions are in place for a future permanent generator. If a temporary generator is needed in the event of an outage to both independent utility services, provisions are in place to temporary cable a large portable generator through a manhole, duct bank and cable tray system to the generator breaker in the substation switchgear
* Plant 2 electrical improvements, including two new 500 kW transformers and switchgear.
* Pump Station No. 4 improvements, including new switchgear and VFD for HSP #1.

EXAMPLES – EXAMPLES – EXAMPLES – EXAMPLES – EXAMPLES – EXAMPLES	
Water Mains	500 feet of 8-inch water main in First Street from Main Street north to State Street. **OR** 250 feet of 12-inch water main in Clark Road from an existing 8-inch main in Third Avenue north to a hydrant.
Booster Stations	A booster station located at the southwest corner of Third Avenue and Main Street, and equipped with two, 15 Hp pumps each rated 150 gpm @ 200 feet TDH. Station includes backup power and all other equipment as required for proper operation.
Elevated Storage Tank	A 300,000 gallon elevated storage tank located in City Park. The proposed tank shall be spherical, all welded construction and supported on a single pedestal. The tank shall be 150 feet in height, 40 feet in diameter with a normal operating range of 130 – 145 feet. The interior coating system shall be ANSI/NSF Standard 61 approved or equivalent. The tank will be equipped with a cathodic protection system, and includes a tank level control system with telemetry.
Chemical Feed	A positive displacement chemical feed pump, rated at 24 gpd @ 110 psi to apply a chlorine solution for Well No. 1. Chlorine is 12.5% NaOCL, ANSI/NSF Standard 60 approved and will be applied at a rate of 1.0 mg/l of actual chlorine.
Water Supply Well	Well No. 3, a 200 foot deep well with 170 feet of 8-inch casing and 30 feet of 8-inch, 10 slot screen. The well will be equipped with a 20 Hp submersible pump and motor rated 200 gpm @ 225 feet TDH, set at 160 feet below land surface.
Treatment Facilities	A 5 million gpd water treatment plant located at the north end of Second Avenue. The facility will include 6 low service pumps, 2 rapid mix basins, 4 flocculation/sedimentation basins, 8 dual media filters, 3 million gallon water storage reservoir and 6 high service pumps. Also included are chemical feed pumps and related appurtenances for the addition of alum, fluoride, phosphate and chlorine.

General Project Information – Complete all boxes below.	
7. Design engineer's name, engineering firm, address, phone number, and email address: Jeremy N. Nakashima, PE Lockwood, Andrews & Newnam, Inc. 1 Oakbrook Terrace, Suite 207 Oakbrook Terrace, IL 60181 630-495-4123 / jnnakashima@lan-inc.com	8. Indicate who will provide project construction inspection: ☒Organization listed in Box 1. ☒Engineering firm listed in Box 7. ☐Other - name, address, and phone number listed below.
9. Is a basis of design attached? ☒YES ☐NO If no, briefly explain why a basis of design is not needed. Submitted previously under separate cover.	
10. Are sealed and signed engineering plans attached? ☒YES ☐NO If no, briefly explain why engineering plans are not needed. Plans and specs submitted previously under separate cover.	
11. Are sealed and signed construction specifications attached? ☒YES ☐NO If specifications are not attached, they need to be on file at DEQ.	
12. Were Recommended Standards for Water Works, Suggested Practice for Water Works, AWWA guidelines, and the requirements of Act 399 and its administrative rules followed? ☒YES ☐NO If no, explain which deviations were made and why.	
13. Are all coatings, chemical additives and construction materials ANSI/NSF or other adequate 3rd party approved? ☒YES ☐NO If no, describe what coatings, additives or materials did not meet the applicable standard and why.	
14. Are all water system facilities being installed in the public right-of-way or a dedicated utility easement? (For projects not located in the public right-of-way, utility easements must be shown on the plans.) ☐YES ☒NO If no, explain how access will be obtained. Most work will be on City owned property, except forcemain.	
15. Is the project construction activity within a wetland (as defined by Section 324.30301(d)) of Part 303, 1994 PA 451? ☐YES ☒NO If yes, a wetland permit must be obtained.	
16. Is the project construction activity within a 100-year floodplain (as defined by R 323.1311(e)) of Part 31, 1994 PA 451, administrative rules? ☐YES ☒NO If yes, a flood plain permit must be obtained.	
17. Is the project construction activity within 500 feet of a lake, reservoir, or stream? ☒YES ☐NO If yes, a Soil and Erosion Control Permit must be obtained or indicate if the owner listed in box 2 of this application is an Authorized Public Agency (Section 10 of Part 91, 1994 PA 451) ☐ Owner is APA.	

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

Permit Application for Water Systems (Continued)

18. Will the proposed construction activity be part of a project involving the disturbance of five (5) or more acres of land?
☐YES ☒NO
If yes, is this activity regulated by the National Pollutant Discharge Elimination System storm water regulations?
☐YES: NPDES Authorization to discharge storm water from construction activities must be obtained.

☐NO: Describe why activity is not regulated:
Please call 517-241-8993 with questions regarding the applicability of the storm water regulations.

19. Is the project in or adjacent to a site of suspected or known soil or groundwater contamination?
☐YES ☒NO

If yes, attach a copy of a plan acceptable to the DEQ for handling contaminated soils and/or groundwater disturbed during construction. Contact the local DEQ district office for listings of Michigan sites of environmental contamination.

20. IF YOU ARE A CUSTOMER/WHOLESALE/BULK PURCHASER, COMPLETE THE FOLLOWING

1) Name and WSSN of source water supply system (seller) ______

2) Does the water service contract require water producer/seller to review and approve customer/wholesale/bulk purchaser water system construction plans?
☐YES ☐NO

If yes to #2, the producer/seller approval letter must be attached when submitted to DEQ.

21. **Owner's Certification** The owner of the proposed facilities or the owner's authorized representative shall complete the owner's certification. It is anticipated that the owner will either be a governmental agency (city, village, township, county, etc.) or a private owner (individual, company, association, etc.) of a Type I public water supply.

OWNER'S CERTIFICATION

I, BRENT F. WRIGHT (print) (name), acting as the WATER PLANT SUPERVISOR (print) (title/position) for

CITY OF FLINT (print) (entity owning proposed facilities) certify that this project has been reviewed and approved as detailed by the Plans and Specifications submitted under this application, and is in compliance with the requirements of 1976 PA 399, as amended, and its administrative rules.

[signature] 3-31-2014 (810)787-6537
Signature* Date Phone

*Original signature only, no photocopies will be accepted.

EQP5877 (Rev. 6/2012)

5-10-2017 SOM-Flood 0154215

EXHIBIT H

WATER RESEARCH FOUNDATION
ADVANCING THE SCIENCE OF WATER®

EPA

Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water

Subject Area: Infrastructure

Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water

WATER RESEARCH FOUNDATION

ADVANCING THE SCIENCE OF WATER®

About the Water Research Foundation

The Water Research Foundation (formerly Awwa Research Foundation or AwwaRF) is a member-supported, international, 501(c)3 nonprofit organization that sponsors research to enable water utilities, public health agencies, and other professionals to provide safe and affordable drinking water to consumers.

The Foundation's mission is to advance the science of water to improve the quality of life. To achieve this mission, the Foundation sponsors studies on all aspects of drinking water, including resources, treatment, distribution, and health effects. Funding for research is provided primarily by subscription payments from close to 1,000 water utilities, consulting firms, and manufacturers in North America and abroad. Additional funding comes from collaborative partnerships with other national and international organizations and the U.S. federal government, allowing for resources to be leveraged, expertise to be shared, and broad-based knowledge to be developed and disseminated.

From its headquarters in Denver, Colorado, the Foundation's staff directs and supports the efforts of more than 800 volunteers who serve on the board of trustees and various committees. These volunteers represent many facets of the water industry, and contribute their expertise to select and monitor research studies that benefit the entire drinking water community.

The results of research are disseminated through a number of channels, including reports, the Web site, Webcasts, conferences, and periodicals.

For its subscribers, the Foundation serves as a cooperative program in which water suppliers unite to pool their resources. By applying Foundation research findings, these water suppliers can save substantial costs and stay on the leading edge of drinking water science and technology. Since its inception, the Foundation has supplied the water community with more than $460 million in applied research value.

More information about the Foundation and how to become a subscriber is available on the Web at **www.WaterResearchFoundation.org**.

Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water

Prepared by:
Caroline Nguyen, **Kendall Stone**, **Brandi Clark**, and **Marc Edwards**
Virginia Tech, Blacksburg, VA 24061

Graham Gagnon and **Alisha Knowles**
Dalhousie University, Halifax, NS, Canada

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6666 West Quincy Avenue, Denver, CO 80235-3098
and

U.S. Environmental Protection Agency
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Published by:

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FOREWORD

The Water Research Foundation (Foundation) is a nonprofit corporation that is dedicated to the implementation of a research effort to help utilities respond to regulatory requirements and traditional high-priority concerns of the industry. The research agenda is developed through a process of consultation with subscribers and drinking water professionals. Under the umbrella of a Strategic Research Plan, the Research Advisory Council prioritizes the suggested projects based upon current and future needs, applicability, and past work; the recommendations are forwarded to the Board of Trustees for final selection. The Foundation also sponsors research projects through the unsolicited proposal process; the Collaborative Research, Research Applications, and Tailored Collaboration programs; and various joint research efforts with organizations such as the U.S. Environmental Protection Agency, the U.S. Bureau of Reclamation, and the Association of California Water Agencies.

This publication is a result of one of these sponsored studies, and it is hoped that its findings will be applied in communities throughout the world. The following report serves not only as a means of communicating the results of the water industry's centralized research program but also as a tool to enlist the further support of the nonmember utilities and individuals.

Projects are managed closely from their inception to the final report by the Foundation's staff and large cadre of volunteers who willingly contribute their time and expertise. The Foundation serves a planning and management function and awards contracts to other institutions such as water utilities, universities, and engineering firms. The funding for this research effort comes primarily from the Subscription Program, through which water utilities subscribe to the research program and make an annual payment proportionate to the volume of water they deliver and consultants and manufacturers subscribe based on their annual billings. The program offers a cost-effective and fair method for funding research in the public interest.

A broad spectrum of water supply issues is addressed by the Foundation's research agenda: resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide the highest possible quality of water economically and reliably. The true benefits are realized when the results are implemented at the utility level. The Foundation's trustees are pleased to offer this publication as a contribution toward that end.

David E. Rager
Chair, Board of Trustees
Water Research Foundation

Robert C. Renner, P.E.
Executive Director
Water Research Foundation

ACKNOWLEDGMENTS

The authors of this report would like to thank Traci Case, the Water Research Foundation project manager, and the members of the Project Advisory Committee – Christopher Hill, France Lemieux, Joseph Marcinko, and Anne Spiesman. Thanks also to Alexander Vetrovs of HDR for maintaining the pilot study.

We also appreciate the assistance of the following water utilities and organizations for their cooperation and participation in this project: Davidson Water, City of Durham (NC), Greenville Utilities Commission (NC), Halifax Water (Nova Scotia), Jordan Valley Water Conservancy District (UT), Long Beach Water (CA), City of Minneapolis (MN), City of Montreal, Portland Water Bureau (OR), City of Raleigh (NC), City of Savannah, South Blount County Utility District, Ville de Laval (Quebec), Washington Suburban Sanitary Commission (MD), CDM, and the Copper Development Association, Ecole Polytechnique Montreal. We would also like to thank Jerry Lowry for assistance with the case study in Maine.

EXECUTIVE SUMMARY

The leaching of lead to potable water can sometimes be severely impacted by seemingly innocuous changes in water treatment including changes from one coagulant type to another. Case studies documented a few prior instances in which coagulant changes produced a higher chloride-sulfate mass ratio (CSMR) in the finished water that was linked to the onset of lead contamination problems. However, no mechanistic studies had been conducted to unambiguously demonstrate the precise sequence of events that can cause higher a CSMR to increase lead contamination.

The Water Research Foundation funded this project to determine the effects of CSMR on lead leaching to potable water. The work was performed in three phases. In Phase 1, the fundamental chemistry of galvanic corrosion attack on lead-copper joints was evaluated, and experiments examined impacts of high CSMR on the integrity of soldered joints. Utility case studies were evaluated in the second phase of work to examine effects of CSMR on galvanic corrosion in a number of potable waters. Specifically, questions regarding the effects of coagulant changeover, desalination, and anion exchange treatment on lead solder and leaded brass corrosion were evaluated. The roles of alkalinity, pH, and corrosion inhibitors to potentially mitigate corrosion in high CSMR waters were also examined. Finally, in a third phase of work, re-circulating loops were used to evaluate the impacts of chloride, sulfate, and flow rate on corrosion of lead plumbing materials.

A total of six conference papers on this work have been presented to date:

- Nguyen, C.; Edwards, M.; Stone, K.; Clark, B. Mechanistic Effects of Chloride-to-Sulfate Ratio on Lead Corrosion. 2008 AWWA Annual Conference. Atlanta, GA. Presentation TUE16. June 2008.
- Stone, K.; Nguyen, C.; Edwards, M.; Clark, B. Effects of Coagulant and Other Treatment Changes on Lead Leaching. 2008 AWWA Water Quality Technology Conference. Cincinnati, OH. November 2008.
- Stone, K.; Nguyen, C.; Edwards, M. Practical Identification and Resolution of Lead Corrosion Issues Due to Elevated Chloride-to-Sulfate Mass Ratio. 2009 AWWA Annual Conference. San Diego, CA. Presentation WED32-2:30. June 2009.
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APPLICATIONS AND GENERAL GUIDANCE

Level of Utility Concern Relative to CSMR

The chloride-to-sulfate mass ratio (CSMR) is calculated based on effluent sample results. For example, for water with 10 mg/L Cl^- and 20 mg/L SO_4^{2-}, the CSMR is 0.5:

$$\text{Chloride to Sulfate Mass Ratio (CSMR)} = \frac{[Cl^-]}{[SO_4^{2-}]} = \frac{10\ \text{mg/L}\ Cl^-}{20\ \text{mg/L}\ SO_4^{2-}} = 0.5$$

To judge whether the information in this report is of no concern, significant concern, or a serious concern, utilities can use the flow chart (Figure ES.1) and the calculated CSMR of their water. For example, if a utility has no lead solder or partially replaced lead pipe materials in the distribution system and the CSMR is below 0.2, in general this report would not predict lead problems from the mechanism of lead corrosion that is described herein. In contrast, if a utility has a CSMR greater than 0.5 and an alkalinity of less than 50 mg/L as $CaCO_3$, then the utility could potentially have serious lead problems following treatment changes that increase the CSMR. The greatest concerns are at utilities with lead solder or partially replaced lead pipe, that are considering changes to their water chemistry that increase the water's CSMR from below 0.5 (before) to above 0.5 (after). It is strongly recommended that utilities considering treatment changes that increase CSMR above 0.5 examine potential impacts on lead release using simple protocols described in this work. Most of the tests can detect adverse impacts after just a few weeks of bench scale testing.

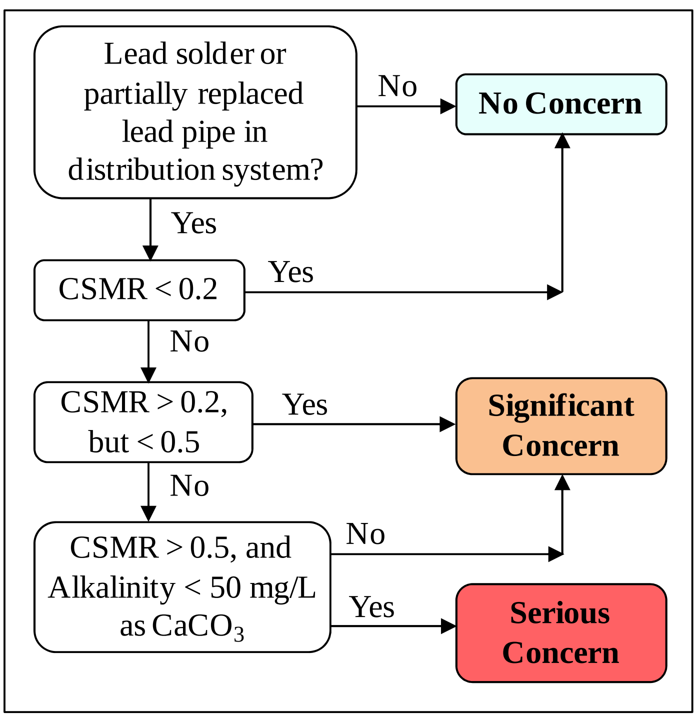


Figure ES.1 Level of lead concern relative to CSMR of water

Guide to Using This Report Most Efficiently

A roadmap to the report is provided to assist utilities, regulators, and scientists in determining which portions of this work would be of greatest interest in their particular situation (Figure ES.2). Utilities with significant to serious lead concerns from CSMR, as determined from Figure ES.1, are strongly encouraged to consider the relevant portions of this work.

The key point of this work is that elevated chloride and reduced sulfate can sometimes markedly increase the lead leaching in consumers' homes and 90th percentile lead values obtained through utility monitoring. Numerous treatment changes can increase the relative amount of chloride and sulfate in the water including: 1) switching from chlorine gas to hypochlorite generation using brine solutions, 2) changing from a sulfate-containing coagulant such as alum to a chloride-containing coagulant such as ferric chloride, 3) anion exchange for arsenic treatment, 4) desalination, and 5) increasing chloride in raw water due to road salt use. Methods that might reduce or eliminate the adverse effects of higher chloride (or lower sulfate) were also evaluated in this project. In general, water quality changes that mitigate most lead corrosion problems including phosphate dosing or modest adjustments to alkalinity/pH, were largely ineffective in controlling lead leaching problems from lead solder or lead pipe that is galvanically connected to copper. Thus, findings of this work may be viewed as a special manifestation of lead corrosion problems, which requires specialized considerations and expertise to solve.

BACKGROUND

Much of the prior research on lead leaching has focused on corrosion as it relates to bulk water parameters including pH, alkalinity and orthophosphate concentration. Utilities have had a great deal of success applying solubility concepts to mitigation of lead leaching from pure lead pipe, lead solder, and brass. Galvanic corrosion between dissimilar metals can cause a dramatic divergence from this conceptualization in some circumstances and have relatively little effect in others. Specifically, if there is little or no galvanic current between electrically connected dissimilar metals such as lead and copper, then the concentration of constituents at the surface of the solder will be close to that of the bulk water. In those circumstances, prior insights regarding the role of water chemistry on lead solubility under pH, alkalinity, and anion levels would directly apply and solve most problems (Schock et al. 1996). Although lead in water can be in particulate form as well as soluble form (McNeill et al. 2004), the general trends in lead solubility often serve as a useful guide for predicting changes in total lead concentration that will occur in drinking water.

However, if significant galvanic currents exist, localized conditions arise which can decouple the chemistry present at the lead surface from that present in the bulk water. Specifically, pHs at the surface of lead solder can be driven to as low as pH 2, and the local Cl^- and SO_4^{2-} levels in the water contacting the lead can be orders of magnitude higher than in the bulk water. Under such circumstances, conventional approaches to mitigating lead corrosion can be rendered almost completely ineffective. To address gaps in understanding and to provide a basis for responding to problems, this work attempted to: 1) extend prior practical research on lead solubility to the range of chemical conditions that may be present at lead anode surfaces, 2) unambiguously demonstrate mechanisms of the serious corrosive attack that can occur on lead

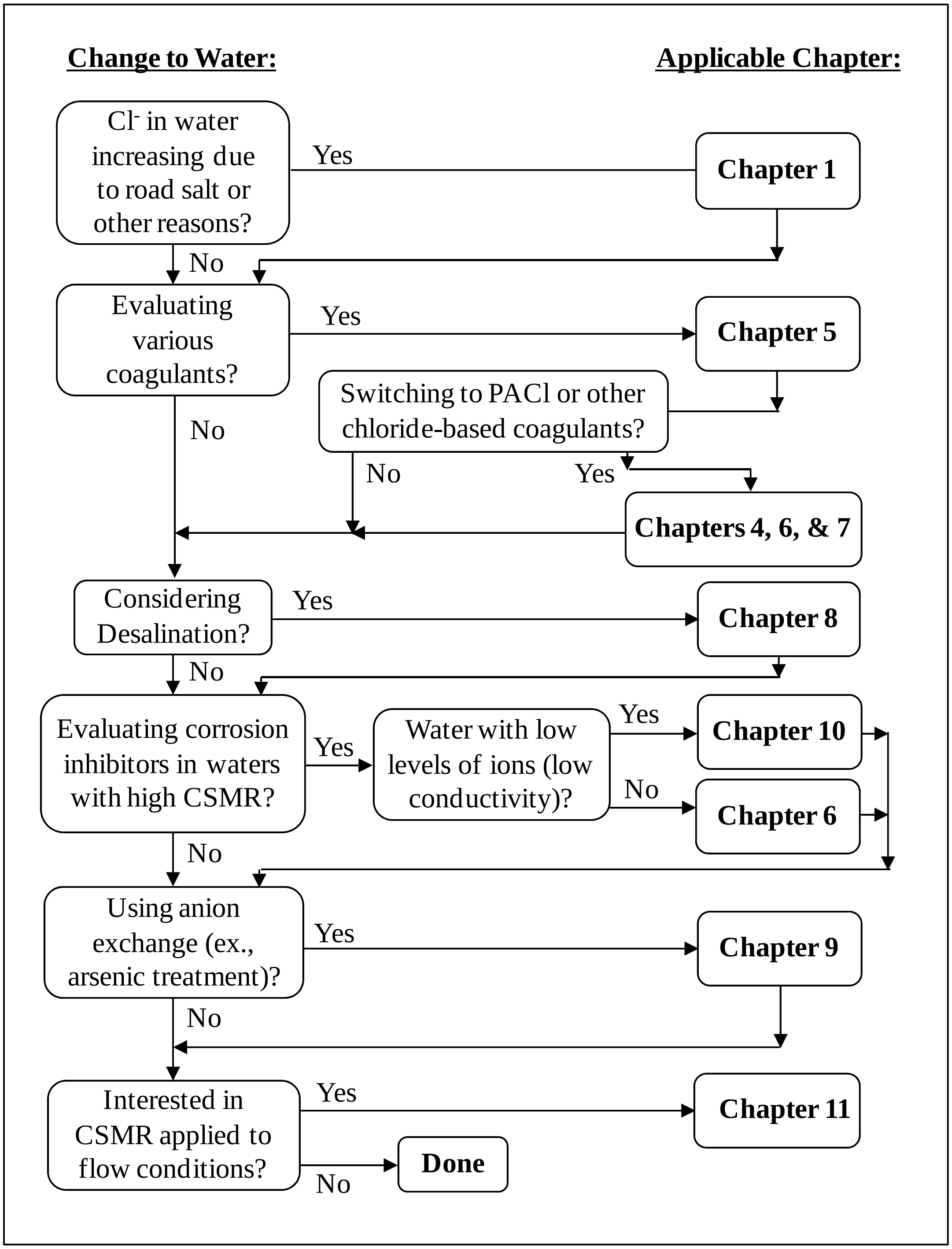


Figure ES.2 Applications decision tree. This tree is intended to provide direction for the reader in finding the relevant chapter(s) based on their individual situations and applications. If the reader determines that changes to treated water would affect the CSMR, and these changes could create a significant or serious level of concern, the tree can direct them to the applicable research and help them mitigate a potentially corrosive situation. Note: this tree is meant as a reference guide to find research information and not intended to be used as an absolute water treatment reference manual.

solder in waters with high CSMR, and 3) systematically evaluate a range of water treatment changes that might alter CSMR through case studies at participating utilities.

At the outset it is important to note that CSMR impacts on galvanic corrosion and associated lead contamination of potable water can be controlled by a number of factors that may include but are not necessarily limited to: 1) type of lead plumbing material, 2) type of passivating film coating the lead or copper surface, 3) frequency of water flow patterns in the building, 4) plumbing connections to other pipe materials including iron, 5) workmanship of the plumber who originally installed the lead:solder joints, which controls the mass of solder exposed to the water, and 6) history of water chemistry in the plumbing system. Moreover, although this work did not identify specific trace water chemistry constituents that could be present (or added) to water that could completely stop this type of attack, it is also quite possible that such trace constituents exist in certain systems. Considering these factors, trends found in this work are not expected to apply universally to lead contamination events in individual homes/buildings, or even at specific water utilities, because additional research is needed to better understand the practical circumstances when severe lead contamination from galvanic corrosion is triggered. However, based on prior research and the case studies presented herein, it is clear that the discoveries presented in this work do apply to lead corrosion problems at some utilities.

APPROACH

Static dump-and-fill experiments were conducted in triplicate for the first phase of work examining fundamental chemistry and solder corrosion. Effects of water chemistry on total, soluble, and complexed lead were determined. Lead, tin, antimony, pH and chloride near the solder (anode) surface, galvanic currents, and peak structural loads before joint failure were measured. A quality assurance and quality control (QA/QC) plan was developed, approved, and followed for all laboratory work in this project.

In a second phase of work, water was shipped from participating utilities to Virginia Tech. The waters from the utilities were treated at bench scale to simulate the full-scale treatment to the extent possible using coagulation, sedimentation, filtration, and disinfection. For the case studies where the coagulant type was evaluated, attempts were made to treat the waters exactly the same as they would be in practice, except for the type of coagulant used. Although there were some differences in finished water turbidity and organic carbon levels (as would occur in practice), the major difference in the treated finished water was almost always the amount of counter-ion added to the water from the coagulant (i.e., sulfate from coagulants such as alum or ferric sulfate, and chloride from coagulants such as PACl or ferric chloride). A range of inhibitor types, alkalinity levels, and pHs were also examined to see if they mitigated or exacerbated the corrosion and resulting lead contamination (Table ES.1). Solder-copper coupons and sometimes brass were exposed to fresh test water twice per week, but water was otherwise stagnant. Total lead in water and pH near the solder surface were amongst the measurements used to track practical impacts resulting from treatment.

In the final phase of the work, water was recirculated through pipe loops containing lead plumbing materials and copper pipes while exposed to low and high CSMR water. The water in the reservoir for each loop was changed weekly. Total lead was measured weekly in the reservoir for each condition and from pipes before and after stagnation periods. The galvanic current flowing between the copper pipe and the lead plumbing material was measured at least

Table ES.1
Variables investigated in each bench scale test.

	Utility Case Study									
Variables	**I, MD**	**A, NC**	**G, NC**	**B, NC**	**E, NC**	**D, Nova Scotia**	**K, CA**	**F, ME**	**J, TN**	**H, WA**
Alkalinity	■	■			■				■	
Anion Exchange					■			■		
NH_2Cl vs. Cl_2	■									
Cl- Leak from Chlorine Generation									■	
Coagulant Type	■	■	■	■	■	■				
pH									■	
Phosphate Inhibitors		■		■	■				■	
Road Salt	■									
Chapter in Report	***1***	***4***	***5***	***6***	***6***	***7***	***8***	***9***	***10***	***11***

■ Completed as part of the Water Research Foundation Project 4088

weekly for the loops containing two dissimilar metals. The lead and current data were used to examine the effects of high and low CSMR water on a range of lead plumbing materials with more frequent flow conditions compared to the second phase of work.

RESULTS

Lead leaching from lead plumbing materials increased when the chloride-to-sulfate mass ratio (CSMR) of the water was increased for almost all of the cases evaluated in this report. As CSMR increased towards the ratio of 0.4-0.6, changes in the CSMR had particularly strong impacts, consistent with prior experiences and experiments. If CSMR was well above 0.4-0.6, then further increases in CSMR were detrimental but did not produce large percentage increases in lead leaching. Experiences of utilities were synthesized and documented, illustrating that substantive increases in CSMR and lead problems can be triggered by the following:

1) changing from a sulfate-based coagulant to a chloride-based coagulant,
2) using anion exchange (resin in chloride form),
3) using desalinated or membrane treated water,
4) road salt runoff from roadways, and
5) chloride leaks from hypochlorite generation system using brine.

Mechanistic Effects of CSMR

The key reactions occurring at the lead surface were examined using a combination of solubility tests and macro-cell arrangements. Sulfate in water can be beneficial because it reacts with lead in the water to form relatively insoluble $PbSO_4$ solids, even at pHs as low as 2 to 5. In contrast, chloride does not tend to form insoluble lead solids at these pHs, but instead enhances the dissolution of lead by forming soluble complexes such as $PbCl^+$. The net result is that sulfates mitigate lead contamination from lead surfaces galvanically coupled to copper, by reducing the magnitude of the galvanic current and also by forming a relatively low solubility scale layer. In contrast, chloride increases the magnitude of the galvanic current and prevents formation of a protective scale layer. The net result is that under conditions found at lead anode surfaces, SO_4^{-2} is beneficial in reducing lead release, and Cl^- is detrimental. This is the mechanistic basis for the CSMR ratio in predicting lead contamination from galvanic corrosion. A higher CSMR has relatively little effect on corrosion of lead pipe or lead solder that is not galvanically connected to copper.

Coagulant Changeover Case Studies

In practical case studies, coagulation with a chloride-based coagulant (e.g., ferric chloride) tended to increase lead leaching from simulated copper joints containing 50:50 Pb/Sn solder compared to coagulation with a sulfate-based coagulant such as alum. The differences between lead contaminants caused by coagulant selection were most dramatic when the CSMRs of the treated waters were below the threshold value of 0.5 before the switch, and were raised to greater than 1.0 after the switch. In this project, a wide range of chloride-based, sulfate-based, and blended coagulants were evaluated (Table ES.2).

For one utility in NC (Utility G) simulated solder-copper joints exposed to ferric chloride or a ferric sulfate/aluminum chlorohydrate blend leached at least 3 times more lead than the sulfate-based coagulants (e.g., alum). Further evidence of the positive correlation between CSMR and lead release was observed for two utilities in NC (Utilities B and E), where ferric chloride-treated water released 3 times and 6 times more lead from brass and solder, respectively, than ferric sulfate-treated water. Consistent with expected trends, the ferric sulfate/chloride blended water that had a CSMR of 0.3 leached significantly less lead from solder than the water with the highest CSMR (ferric chloride) and released more lead from solder than ferric sulfate, which had the lowest CSMR.

Similarly, PACl-treated water for Greenville in NC released 50 times more lead from 50:50 Pb/Sn solder than alum-treated water after 23 weeks. However, when the coagulant was changed for Greenville from alum to PACl at bench scale, the lead leaching did not increase markedly until after 2 weeks of exposure. Therefore, dosing PACl during storm events for a few days at the plant should not have major negative consequences for lead leaching in this system.

The effect of CSMR was not as obvious for a utility in Maryland (Utility I) and a utility in Nova Scotia (Utility D). This may be attributed to the consistently high CSMR of the treated water, regardless of which coagulant was used, because the CSMR was always well over the critical range of 0.5. No significant difference was observed for Utility I comparing alum and PACl in terms of lead leaching from brass and 50:50 Pb/Sn solder in this water. However, there

Table ES.2
Summary of coagulants evaluated in the EPA/Water Research Foundation Project 4088.

Utility	Chapter in Report	Coagulants Evaluated	CSMR Tested	Summary of Findings and Other Considerations
Greenville Utilities Commission (GUC), NC	4	Alum	0.4	After switching from alum to PACl, it took 1.5 weeks for lead leaching to increase. Coupons exposed to low and high CSMR waters for 2 years showed no differences between the CSMRs. For this water, blending coagulants to achieve a CSMR of approximately 0.7 did not significantly increase lead leaching, and changes in alkalinity did not have a large effect on lead leaching compared to the effects of CSMR.
		Alum/PACl Blends	0.7	
			1.1	
			1.5	
		PACl	1.8	
B & E, NC	6	Ferric Sulfate	0.2	Water treated with ferric chloride consistently had more lead leaching from solder and brass than water treated with ferric sulfate. Anion exchange treatment in conjunction with ferric chloride coagulation resulted in the highest lead levels, and phosphate corrosion inhibitors made lead leaching worse for that CSMR condition.
		Ferric Sulfate/ Ferric Chloride Blends	0.3	
			1	
		Ferric Chloride	4.5	
D, Nova Scotia, Canada	7	Alum	0.9	Lead release from Pb/Sn solder was not significantly different among the three water conditions tested. This might be because all waters were above the 0.5 CSMR threshold. At levels of CSMR above the 0.5 threshold, other factors such as alkalinity and organic carbon may control lead release.
		Ferric Sulfate	0.9	
		PACl	2.1	
G, NC	5	Alum	0.4	Chloride-based coagulants, which had CSMRs >1, had significantly higher lead levels than sulfate-based coagulants (CSMR of 0.4)
		Ferric Sulfate	0.4	
		Ferric Sulfate Polymer Blend	0.4	
		Ferric Sulfate/ Aluminum Chlorohydrate Blend	1.8	
		Ferric Chloride	3.1	
I, MD	1	Alum	1.4	Both CSMR levels that were evaluated resulted in high lead release from brass and solder. Because of the high CSMR of the waters evaluated, no significant differences were seen between PACl and alum in terms of lead leaching. However, PACl water dosed with simulated road salts (CSMR 8.4) resulted in about two times more lead than PACl or alum waters (with no road salts).
		PACl	5.3	

was evidence that a very high CSMR could result in some increase in lead leaching. Specifically, when PACl-treated water was dosed with 20 mg/L Cl to simulate the upward trend in raw water chloride from road salt runoff (CSMR 8.4), lead leaching doubled compared to the other two conditions with no simulated road salt runoff. Similarly, the CSMR for Utility D water was always relatively high (CSMR > 0.9), and therefore other factors such as organic carbon and alkalinity had a greater effect on lead leaching than did changes in CSMR. It is hypothetically possible that in systems with high CSMR, much of the solder that was exposed to water has been released over decades of corrosion. A substantial fraction of the simulated solder from worst-case joints leached to the water over a period of months to years. Hence, such systems might not be adversely impacted by higher CSMR water, relative to systems that passivated rapidly in a low CSMR water when first installed and abruptly subjected to high CSMR water. This might also explain compliance with 90^{th} percentile lead levels in systems that have historically had high CSMR water.

Case Studies Evaluating the Effect of CSMR from other Treatment Changes

Desalinated water tends to contain relatively low levels of sulfate but high amounts of chloride, since the treatment process more efficiently removes sulfate from the water than chloride. Blending desalinated water with the current distribution water (groundwater) used at Utility K increased lead release from lead solder galvanically connected to copper by 18 times when the blended water consisted of 25% desalinated water in bench scale tests. In the highest blend evaluated, lead release increased more than 40 times when the blend contained 75% desalinated water. Further testing indicated that the detriments of high CSMR could not be countered by higher alkalinity or phosphate corrosion inhibitors in this water.

Another treatment change that impacted the CSMR of treated water is anion exchange, which is used to remove contaminants such as arsenic and organic matter from water. For one utility in Maine (Utility F), treating with anion exchange increased the CSMR of the water from 1.1 in the distribution water to 7.8 after anion exchange treatment. The lead release from 50:50 Pb/Sn solder reflected the impact of the CSMR, since an average of 47 times more lead was released from the coupons exposed to anion exchange treatment over the six-week study period compared to the coupons with no treatment. The dramatic increase in lead observed in practice in this water system after starting anion exchange treatment may also be attributed to the decrease in pH and alkalinity after anion exchange treatment. However, a major contributor to the problem, even in the absence of a pH drop, was the higher CSMR.

Effect of Alkalinity

Increasing the alkalinity for waters from Utilities A, E, and I decreased the lead released to the water. Thus, from this perspective alkalinity was beneficial as was predicted. However, adding alkalinity to a very low conductivity water from Utility J exacerbated lead release. Furthermore, the combination of orthophosphate and increased alkalinity made lead leaching much worse. Additional research is needed to better understand when alkalinity will have beneficial or detrimental effects.

Corrosion Inhibitors

The effects of phosphate are complex and were dependent on the water tested. Dosing orthophosphate to the water from Utility J, which had very low conductivity, reduced lead leaching from 50:50 Pb/Sn solder. However, when the alkalinity of the water was increased and orthophosphate was dosed, the lead release increased dramatically. Those results are inconsistent with accepted theory, and further research is needed to determine when phosphate would be beneficial or detrimental.

Based on prior field experience, it was known that dosing of phosphate for 18 months to 20 years did not stop problems from lead contamination when CSMR was subsequently increased. However, in bench scale testing for this work, phosphate seemed beneficial in mitigating problems in some cases. For example, addition of orthophosphate at a dose of 1 mg/L P (3 mg/L PO_4) was more effective in reducing lead leaching than polyphosphates or adding no inhibitor in Greenville, NC (Edwards and Triantafyllidou 2007). Lead solder coupons were exposed for at least 3 years to Greenville water containing orthophosphate, most likely with little or no dissolved oxygen during that exposure, and the coupons leached at least 3.5 times less lead than equivalent coupons never exposed to orthophosphate.

In another water tested for Utilities B and E, dosing of orthophosphate also dramatically decreased lead leaching to 25% of the lead release observed in the same water with no inhibitor. Benefits of dosing silicate polyphosphate inhibitor in terms of lead leaching was also achieved for Utilities B and E, but the extent of the decrease in lead release per equivalent amount of phosphate dosed was lower than with orthophosphate.

CONCLUSIONS

Key conclusions that can be taken from this work include:

- A simple bench-scale test protocol was developed that provides insights to changes in lead leaching to water from galvanic connections between solder/lead pipe and copper. This simple dump and fill protocol was successfully used to rapidly screen for significant changes in lead leaching that resulted from various water treatment changes. In most cases, short-term tendencies as measured by the test were in qualitative agreement with practical utility experiences and longer-term test results.
- pH drops at the surface of lead solder or lead pipe, if there is a galvanic connection to copper pipe. pHs as low as 3.3 were measured at the surface of the lead bearing material even when the bulk water pH was 8.0 or higher. (Chapter 1)
- At pH 3, pH 4, and pH 5, the concentration of soluble lead decreased with the addition of high levels of sulfate. Changes in pH in the pH 3-5 range have little effect on the solubility of lead sulfate. The migration of sulfate to lead anode surfaces can therefore serve to limit lead leaching. (Chapter 1)
- At pH 3, 4, and 5, the uncomplexed or free lead concentration decreases with the addition of chloride, consistent with formation of a $PbCl^+$ lead chloride complex. The migration of chloride to lead anode surfaces, therefore, can exacerbate problems with lead leaching. (Chapter 1)
- The net effect of chloride and sulfate migration to lead anode surfaces depends on their relative concentration. Higher chloride tends to increase lead solubility whereas higher

sulfate tends to decrease lead solubility; hence, the usefulness of the CSMR in explaining trends in lead contamination when galvanic corrosion of lead is significant. (Chapter 1)

- The corrosion rate of and the release of lead and/or tin from solder alloys was greater in high CSMR water. The pH at the solder surfaces were measured to be as low as pH 3.0. (Chapter 2)
- Simulated joints with 97/3 Sn/Cu solder had the greatest reduction of joint strength after one year of exposure to high CSMR water. (Chapter 2)
- The 95/5 Sn/Sb had the most desirable characteristics of the solders evaluated in this project. The solder had the lowest reduction in joint strength after one year of exposure to high CSMR water, did not release harmful levels of antimony, and had less tin corrosion compared to other solder alloys. (Chapter 2)
- For the utilities evaluated in this project, leaded brass leached relatively low levels of lead to the water, even in situations with high CSMR. In contrast, corrosion of lead solder in simulated copper joints contributed to very high amounts of lead in test waters. Thus, while leaded brass is impacted somewhat by CSMR, the issues associated with lead solder can occasionally achieve hazardous waste levels (>5,000 ppb) of lead in water under worst-case scenarios. As a result, lead solder and lead pipe galvanically connected to copper are the primary concern when effects of higher CSMR are considered.
- Generally, increasing the chloride-to-sulfate mass ratio (CSMR) of the water results in higher lead levels in water when copper:lead solder or copper:lead pipe galvanic couples are present. There could be higher chloride and lower sulfate in the water due to a range of scenarios:
    - Road salt entering the water supply from runoff, especially into open reservoirs (Chapter 1)
    - Coagulant type (chloride-based vs. sulfate-based) (Chapters 4, 5, 6, and 7)
    - Desalination (Chapter 8)
    - Chloride-based anion exchange treatment (Chapter 6 and 9)
    - Brine leak from hypochlorite generation system (Chapter 10)
- A combination of low pH and high CSMR at the solder surface drive the long-term galvanic corrosion of the lead solder, as demonstrated by local measurements of very high chloride, sulfate, and lead near the lead solder anode. There is no evidence that the lead solder can passivate in such circumstances.
- It is hypothetically possible that in systems with high CSMR, much of the solder that was exposed to water has been released over decades of corrosion. A substantial fraction of the simulated solder from worst-case joints leached to the water over a period of months to years. Hence, such systems might not be adversely impacted by higher CSMR water, relative to systems that passivated rapidly in a low CSMR water when first installed and abruptly subjected to high CSMR water. This might also explain compliance with 90^{th} percentile lead levels in systems that have historically had high CSMR water.
- Increasing alkalinity of the water can be effective in mitigating the low pH at the lead solder surface and eventually causing decreased lead levels. However, in some circumstances where conductivity of the water is very low, increasing the alkalinity (and conductivity) can make lead leaching much worse. Dosing orthophosphate was more effective than polyphosphate in reducing lead release. However, in rare circumstances, dosing orthophosphate could make lead leaching worse. Hence, the effects of phosphate and alkalinity need to be determined on a site-specific basis. With additional experience,

it might be discovered that the adverse effects of higher alkalinity and higher phosphate are limited to certain waters, such as those with extremely low conductivity. (Chapters 6 and 10)

- The effect of CSMR was confirmed in flowing conditions that are typical in home systems. Higher CSMR water resulted in higher lead leaching from lead pipe, bronze pipe, and solder galvanically connected to copper. (Chapter 11)
- The galvanic connection of copper to the lead materials evaluated in the study significantly increased lead leaching when compared to the situation when there was no electrical connection to copper pipe. In some waters, however, galvanic connections had little effect on lead leaching. (Chapter 11)

RECOMMENDATIONS

A key finding was that problems that occur in coagulant changeovers could usually be mitigated by controlling the type of coagulant and keeping CSMR below about 0.5. However, this is not always an option when CSMR was increased via arsenic treatment via anion exchange or desalination. For these case studies, adding orthophosphate when the CSMR was high did not reduce lead leaching or the extent of the problem. Therefore, more work is needed to determine what treatment(s) could counter the adverse consequences of higher CSMR.

This work also focused on making comparisons among treatment methods in terms of leaching from lead solder under worst-case conditions of long stagnation times, and these changes were dramatic. However, it is not completely certain how the lead levels measured in these "worst case" scenarios would translate to 90th percentile lead in practice. Better understanding would require consideration of many factors including plumbing materials in the distribution system, variability in plumbing jobs, and other factors. That is, in some situations, even a 20% increase in lead leaching from solder or lead pipe connected to copper due to higher CSMR might translate to a relatively modest increase (+/- 0.1 to 1 ppb) in 90th percentile lead. In these cases, even though galvanic corrosion of lead bearing materials is worsened, the public health concern might be of relatively low significance.

ORGANIZATION OF THE REPORT

This report is organized as follows:

- Chapter 1 defines the mechanism by which high chloride and low sulfate can increase lead release from solder using a macrocell configuration. A case study with one utility in Maryland demonstrated the impacts of chloride, sulfate, disinfectant type, and alkalinity on lead leaching, pH at the lead surface, and real-time corrosion rates for a simulated lead joint.
- Chapter 2 describes the impact of chloride and sulfate on the durability of simulated copper joints comprised of various solder alloys, including lead solder and lead-free solders. Some types of solder were more resistant to attack in high CSMR waters than others.
- Chapter 3 presents an overview of the factors evaluated in the case studies for this project and provides a framework for the remainder of the report.
- Chapter 4 describes results from the Greenville Utilities Commission (GUC) in North Carolina (NC), where lead in drinking water has been a problem in the past. The

impact of short-term changes in coagulant from a sulfate-based coagulant to a chloride-based coagulant was evaluated. Additionally, blends of alum and PACl coagulants were reviewed, as a potential approach to realizing benefits of PACl coagulation while maintaining a lower level of chloride in the water.

- Chapter 5 is a case study using water from another utility in NC (Utility G), where 5 potential and past coagulants were evaluated for the effects on simulated copper joints and on brass.
- Chapter 6 describes a case study for two utilities in NC that were close in proximity. Coagulants, corrosion inhibitors, and lime (versus caustic) were evaluated.
- Chapter 7 summarizes the impacts of coagulant changes for a utility case study in Nova Scotia, Canada.
- Chapter 8 describes the implications of desalinated water use on lead leaching for one utility in California.
- Chapter 9 describes a case study in Maine where arsenic treatment and low pH both contributed to high levels of lead in water.
- Chapter 10 presents a case study for a utility in Tennessee that has very low conductivity water, and the standard practices for reducing lead in water actually made lead leaching much worse.
- Chapter 11 summarizes the results from the pipe loop study conducted at the HDR ARTC facility. Flow rate, chloride, sulfate, and various lead plumbing materials were evaluated.

CHAPTER 1
MECHANISMS OF ATTACK ON LEAD SOLDER

Caroline Nguyen, Kendall Stone, Brandi Clark, and Marc Edwards

Keywords: Coagulants, polyaluminum chloride, alum, chlorine, chloramines, road salt

INTRODUCTION

Lead corrosion is sometimes severely impacted by seemingly innocuous changes in water treatment. For example, several utilities observed lead contamination problems that arose after changing coagulants from aluminum sulfate to ferric chloride or polyaluminum chloride (PACl). In some cases, the addition of orthophosphate, a standard tool for mitigating many lead problems did not resolve the much higher lead in water produced from this changeover.

A literature review documented numerous prior cases in which higher chloride-to-sulfate mass ratio (CSMR) was linked to lead problems (Edwards and Triantafyllidou 2007). However, no mechanistic studies have ever unambiguously demonstrated the precise sequence of events that could explain the problem. Clearly, galvanic corrosion of lead pipe:copper or lead solder:copper connections is key as demonstrated by Oliphant (1983). Dudi predicted that the pH at the surface of lead materials would dramatically decrease in poorly buffered waters when connected to copper (2004). Edwards and Triantafyllidou confirmed Dudi's prediction and measured pH as low as 3.4 at the solder surface in PACl-treated water compared to pH 7.6-7.8 in the bulk water (2007). In addition, if alkalinity is low enough, pHs as low as 3.0 have been measured at the lead plumbing material surface during stagnation, allowing the attack on the lead-bearing material to proceed indefinitely without passivation (Edwards and Triantafyllidou 2007). Using the findings of prior research, it is possible to conceptualize and anticipate the possible mechanisms by which high CSMR can trigger serious lead galvanic corrosion problems (Figure 1.1).

Considering the galvanic corrosion scenario and associated non-uniform corrosion, there are problems in applying prior research experience to prediction of lead leaching at the lead solder surface. Specifically, if there is no galvanic current between lead and copper in Figure 1.1, then the concentration of constituents at the surface of the lead solder will be that of the bulk water and prior insights regarding the role of water chemistry on lead solubility under pH, alkalinity, and anion levels are relevant (Schock et al. 1996). Although lead in water can be in particulate form as well as soluble form (McNeill et al. 2004), trends in lead solubility often serve as a useful guide for predicting changes in lead concentration that will occur in drinking water as a function of water chemistry. However, if significant galvanic currents exist, which might drive the solder surface pH to 2-5, the prior guidance from the solubility models does not extend to the conditions present at the lead anode surface during stagnation under galvanic corrosion. In those circumstances, the pH can be as low as 2.0, and local Cl^- and SO_4^{2-} levels in the water contacting the lead can be orders of magnitude higher than in the bulk water.

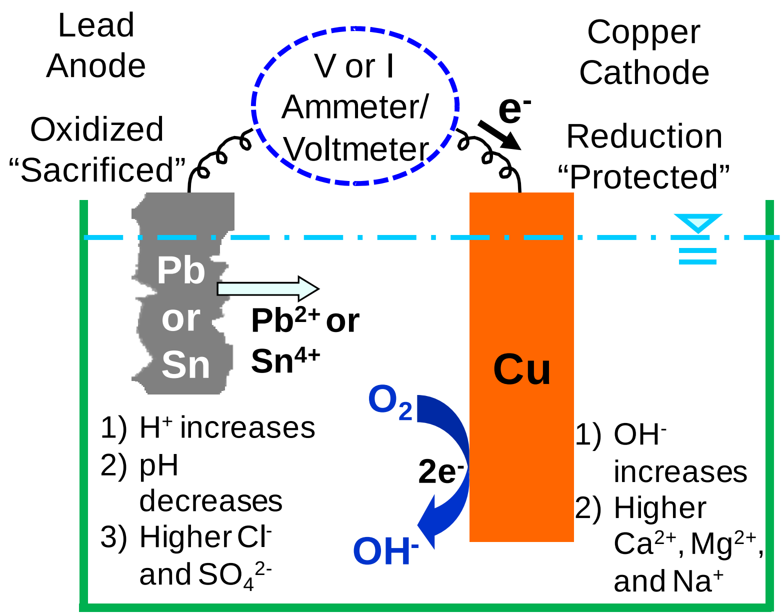


Figure 1.1 Reactions at lead anode and copper cathode surfaces

This work attempts to 1) extend prior practical research on lead solubility to the range of chemical conditions that may be present at lead anode surfaces, and 2) unambiguously demonstrate mechanisms of the serious corrosive attack on lead solder in waters with high CSMR. Bench scale tests were first conducted to examine the solubility behavior of lead in the unusual chemical environment (i.e., lower pH, higher chloride, and higher sulfate) that may be present near the surface of the lead solder when significant galvanic corrosion is occurring. Thereafter, a bench scale case study for Utility I in Maryland was conducted for eight weeks using a specially designed apparatus to mechanistically study the effect of coagulant selection, future water quality trends, and treatment process modifications on lead leaching. After the first two months of the utility case study, additional work was performed to gain confidence in the trends and to evaluate the effects of higher alkalinity and solder orientation in a pipe.

MATERIALS AND METHODS

Lead Solubility and Complexation Studies

Lead speciation for the low pH lead solubility and complexation studies were quantified by a variety of techniques. Soluble lead was operationally defined as the portion of lead that passed through a filter of 0.45 μm nominal pore size syringe filters. Particulate lead was determined as the difference between the total lead and the measured soluble lead, or by dissolution of the solids collected from the water on the surface of the membrane filter. Total, soluble, and particulate lead were quantified via measurements using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) according to Standard Method 3125. All chemicals were added as reagent grade salts.

Sulfate Addition

All solutions were prepared by first dissolving 0.48 mM $Pb(NO_3)_2$ in distilled and deionized water and adding HNO_3 to adjust the solution to pH 3, 4, or 5. The sulfate concentrations in these solutions were varied from 0 to 2.66 mM SO_4^{2-} by adding Na_2SO_4. $NaNO_3$ was added in variable amounts to maintain a constant ionic strength of 0.01 M for each solution (Table 1.1). The pH was then re-adjusted to the target value of pH 3.0, 4.0, or 5.0 ± 0.05 using HNO_3 or NaOH. After 24 hours, unfiltered and filtered (through 0.45 µm pore size nylon filters) samples were collected for each solution and preserved with 2% nitric acid. The lead and sulfate concentrations were measured using ICP-MS.

Chloride Addition

All solutions were prepared by first dissolving 0.48 mM $Pb(NO_3)_2$ in distilled and deionized water and adding HNO_3 to bring the solution to pH 3, 4, or 5. The chloride concentrations in these solutions were then varied from 0 to 8 mM Cl^- by adding NaCl. $NaNO_3$ was added in variable amounts to maintain a constant ionic strength of 0.01 M for each solution (see Table 1.2). The final pH was adjusted to 3.00, 4.00, or 5.00 ± 0.05. After 24 hours, the free Pb concentration was measured, and a sample was collected and preserved with 2% nitric acid to determine the total soluble Pb concentration. Free Pb was measured using a Pb^{2+} ion specific electrode (ISE) manufactured by Cole Parmer, Inc, catalog number 27502-25. The electrode was calibrated using six standards with concentrations ranging from 1 to 300 ppm Pb^{2+} as lead nitrate. The ionic strength of all the standard solutions was maintained at 0.01 M using $NaNO_3$. Measurements were taken immediately following calibration, and the 100 ppm standard was measured periodically to compensate for drift.

Table 1.1
Sulfate and Nitrate Concentrations in Solubility Study

Na_2SO_4 added (mM)	$NaNO_3$ added (mM)
0	8
0.33	7
0.66	6
1.33	4
2	2
2.33	1
2.66	0

Table 1.2
Chloride and Nitrate Concentrations in Complexation Study

NaCl added (mM)	$NaNO_3$ added (mM)
0	8
0.5	7.5
1	7
2	6
4	4
6	2
8	0

Mechanistic Study of Lead Corrosion

Apparatus

Brass. New brass fixtures, such as faucets, are considered major contributors to lead contamination of tap water (Kimbrough 2001, Lytle and Schock 1996, Mariñas et al. 1993). One of the most common types of brass used in faucets is C36000, an alloy with a lead content of 3% by weight. In this test C36000 brass coupons of 0.64 cm (0.25 in) diameter and 0.97 cm (0.38 in) height were fabricated from brass rods. The coupons were epoxied to the bottom of 46-mL glass vials to study corrosion of brass by itself. Each vial was filled with 40 mL of test water in order to achieve a brass surface area to water volume ratio of 8.7 x 10^{-3} in^2/mL. The brass coupons were tested in triplicates and studied only during the first part of the Utility I testing (Part 1).

Solder. Solder wire (50:50 lead:tin) of 0.32 cm (0.125 in) in diameter and with a height of 6.35 cm (2.5 in) was exposed to water in a copper-solder connection (Figures 1.2 and 1.3). The copper portion of the couple consisted of a ¾" diameter copper pipe and a ½" diameter copper pipe, which were connected by clear tubing with an approximate 2-mm gap between the copper pipes. The smaller diameter (½") copper pipe was used to investigate localized effects around the anodic solder. The large diameter (¾") copper had the dual purpose of allowing electrode measurements inside the pipe and providing a large copper-to-solder surface area of approximately 30:1 Cu:Pb total. To simulate the galvanic connection between copper pipes and solder at joints, the solder and the copper pipes were externally connected with copper wires (Figure 1.2). The connection was broken at strategic times throughout the study to place an ammeter in-line electrically to measure the galvanic current and potential drop between the solder and the copper pipes. The schematic and dimensions of the apparatus are provided in Figure 1.2. Three replicates were tested for each water condition in Part 1.

Test Water for Utility I, MD

Part 1. Test water from Utility I in Maryland was obtained at Virginia Tech by shipments of raw water from the Patuxent River reservoir. Collected water was separated and subjected to two simulated treatments, which were otherwise identical except for the type of coagulant used. Treatment involved coagulation with PACl or alum, filtration, phosphate corrosion inhibitor addition, disinfection with free chlorine or chloramines, and final pH

adjustment. The pH for both treatments was adjusted to the same initial value, ranging from 7.6 to 7.8. Since PACl adds chloride to the water, it increases the ratio of chloride to sulfate whereas alum adds sulfate thereby decreasing the ratio. The PACl coagulant was provided by Utility I. Doses, timing of addition and duration of treatments were selected to simulate the full-scale treatment practice to the extent possible.

To simulate future reservoir water quality conditions when road salts enter the source water at higher concentrations, 20 mg/L Cl was added to PACl-treated water in the form of NaCl. An overall upward trend has been observed for raw water chloride concentrations at Utility I over the last 15 to 20 years, with an increase in Cl^- from approximately 10 mg/L in 1990 to 20 mg/L in 2007. Therefore, a total of three CSMR levels were evaluated in this study (Table 1.3).

In addition to the evaluation of CSMR, free chlorine and chloramines disinfectants were also evaluated. For the testing, the two lead materials (lead:tin solder coupled with copper and brass alone) were exposed to six different water conditions (Table 1.3). Each water had a free chlorine or chloramines dose of 3.5 mg/L Cl_2, and all waters were dosed with orthophosphate at a concentration of 1 mg/L P. The alkalinity was approximately 25 mg/L as $CaCO_3$.

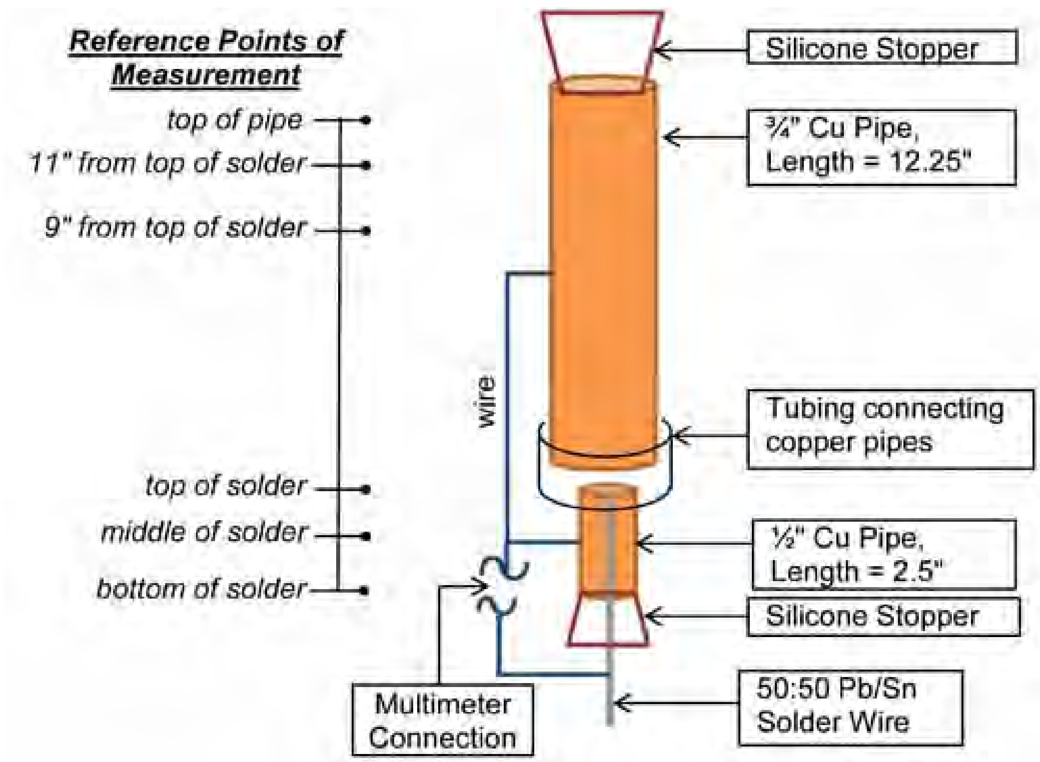


Figure 1.2 Schematic of solder-copper pipe couple used in mechanistic study

Figure 1.3 Picture of solder wire, which extends through the silicone stopper into the center of a ½" copper pipe.

Part 2. Since each test was performed in triplicate, 36 tests (6 x 3 x 2 = 36 with 18 in glass vials and 18 in copper pipes) were conducted overall. During the last ten weeks of the study, the conditions for two of the three replicates of the solder-copper couples were altered. The alkalinity for one replicate was increased from 25 mg/L to approximately 100 mg/L as $CaCO_3$ by the addition of $NaHCO_3$, and for another replicate, the solder-copper couple was turned upside down so that the solder was oriented at the top of the pipe. The last replicate remained at the same condition throughout the entire duration of the experiment and was referred as the "control" for the second part of work. Otherwise, all other parameters including pH, disinfection, and orthophosphate dose remained the same as in the first part of the study. All tests were kept at room temperature throughout the testing period.

Measurements

Exposure of the plumbing materials to water was via a static "dump and fill" protocol three times per week (Monday, Wednesday, and Friday). Therefore, the stagnation time was 48 hours after the Monday and Wednesday water changes, and the stagnation time was 72 hours after Friday until the water change on Monday. The water from each test condition was collected throughout the week, and the unfiltered composite was analyzed for metals at the end of each week. Metals analysis was performed via Induced Coupled Plasma Mass Spectrometry (ICP-MS) in accordance with Standard Method 3125.

Table 1.3
Test Water Conditions for first 8 weeks of Utility I, MD study

Water Conditions	**Chloride** (mg/L Cl)	**Sulfate** (mg/L SO_4)	**CSMR** (mg Cl/ mg SO_4^{2-})
Alum-treated, free chlorine	27	20	1.4
Alum-treated, chloramines	27	21	1.3
PACl-treated, free chlorine	30	6	5.3
PACl-treated, chloramines	32	6	5.3
PACl-treated, road salt (+20 mg/L Cl), free chlorine	48	6	8.5
PACl-treated, road salt, chloramines	48	6	8.4

In addition to metals analysis, pH and chloride measurements were taken for the water near the brass, solder, and copper surfaces using an MI-406 flat membrane pH microelectrode (Microelectrodes, Inc) and a Lazar electrode, respectively. The measurements were taken by slowly lowering the microelectrode from the top of the copper joint, making pH or chloride measurements at 1" and 3" from the top of the pipe. After measuring at the cathode (i.e., top of the joint), the large copper pipe piece was disassembled at the plastic tubing, which connected the large copper section with the small copper. The pH was then measured in the disassembled joint at the solder surface within the smaller copper pipe section. The pH microelectrode was calibrated before each set of measurements, and the localized pH was measured for each triplicate more than three times during the duration of the study. Trends in pH were consistent throughout the study. While it is possible, even likely, that making the measurement disturbed the water, this would manifest itself in making the pH less acidic and closer to the bulk water pH.

Galvanic measurements including current, potential drop, and corrosion potential were performed at least once monthly for the solder-copper couples. Currents and potential drops were measured 1 hour, 24 hours, and 48 hours after a water change 2 or 3 times per month while monthly E_{corr} measurements were performed 1 hour after water was replaced in the pipes.

RESULTS AND DISCUSSION

Low pH Solubility Studies – Effect of Sulfate Addition

The addition of sulfate at pH 3, 4, and 5 caused a large decrease in soluble lead as the amount of sulfate added increased (Figure 1.4). This decrease in lead solubility occurred concurrent with a visible solid that was 100% $PbSO_4$ (ratio of Pb:SO_4 of 0.93 ± 0.09). Formation of $PbSO_4$ was completely consistent with the predictions using default constants in chemical equilibrium modeling software (MINEQL+). Likewise, the pH did not control lead solubility under these conditions, which is expected because the formation of $PbSO_4$ does not involve either H^+ or OH^-.

To identify the composition of the precipitate, samples were dissolved and analyzed by ICP-MS to determine the molar ratio of lead to sulfate. This analysis revealed a molar ratio of lead to sulfate in the precipitate of 0.93 ± 0.09, which is consistent with the predicted formation of $PbSO_4$. Combining these two pieces of evidence, the precipitate is assumed to be $PbSO_4(s)$, which has a K_{sp} expression,

$$K_{sp} = [Pb^{2+}][SO_4^{2-}]$$

The data collected from the experiment was used to calculate an optimized solubility product constant for lead sulfate with a value of 1.54×10^{-8} as determined by fitting data on soluble lead and sulfate (Figure 1.5). This is in good agreement with the default K_{sp} value in the MINEQL database of 1.62×10^{-8}.

Low pH Solubility Studies – Chloride Addition

When the concentration of chloride was varied at pH 3, 4, and 5, no detectable precipitate or decrease in soluble lead occurred. However, the free lead as determined by ion specific electrode decreased with increasing chloride (Figure 1.6). The explanation is that chloride reacts with Pb(II) to form soluble complexes with lead. Using the free and total lead concentrations measured, a K-value can be determined for the formation of $PbCl^{+}$.

The molar concentration of the lead chloride complex was assumed to be equal to the difference between the total soluble lead and the Pb^{2+}. The formation reaction:

$$Pb^{2+} + Cl^{-} \rightarrow PbCl^{+}$$

has an equilibrium expression:

$$K = [PbCl^{+}]/[Pb^{2+}][Cl^{-}]$$

An optimized constant of 59.5 was calculated by combining the data at pH 3, 4, and 5 (Figure 1.7). This value is in reasonable agreement with the default value in the MINEQL database, which was 39.8. The somewhat higher constant suggests that chloride complexation is more significant than previously predicted under these conditions, which have greater practical relevance to conditions found at lead surfaces in potable water.

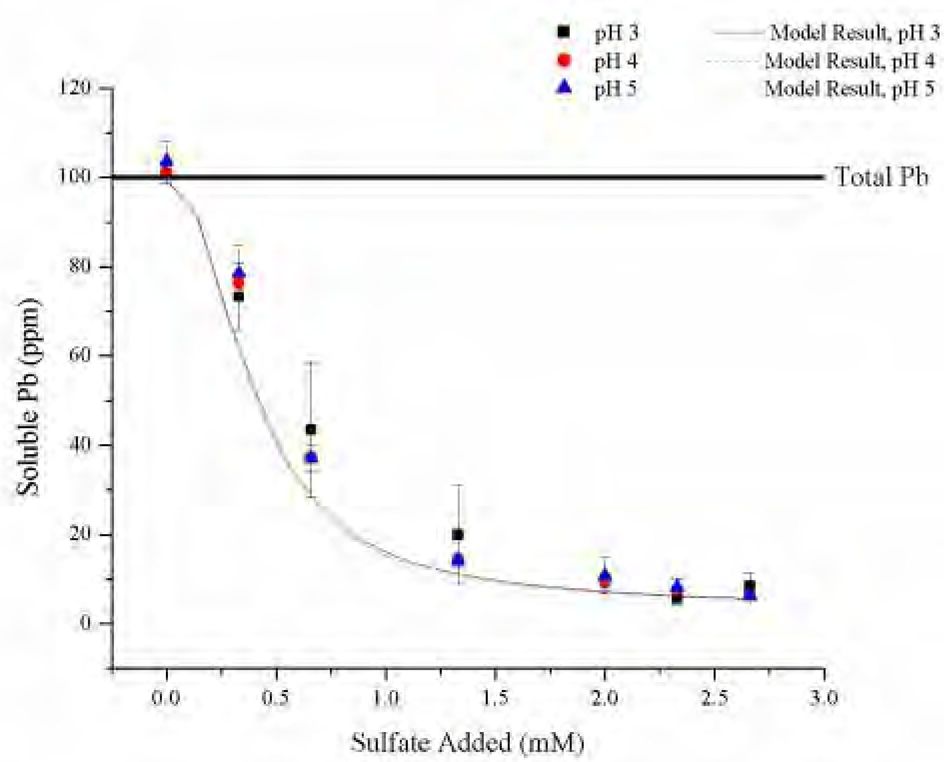


Figure 1.4 Effect of Sulfate Addition on Soluble Lead (error bars indicate 90% confidence interval based on triplicate measurements)

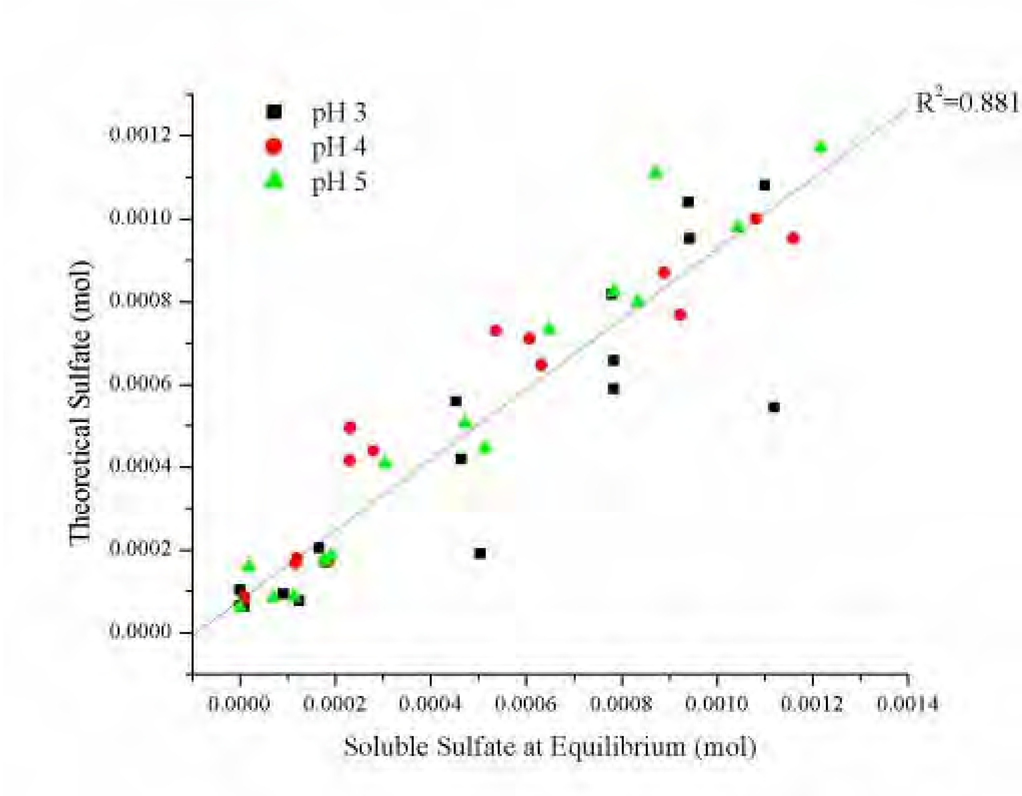


Figure 1.5 Determination of the Solubility Product for Lead Sulfate

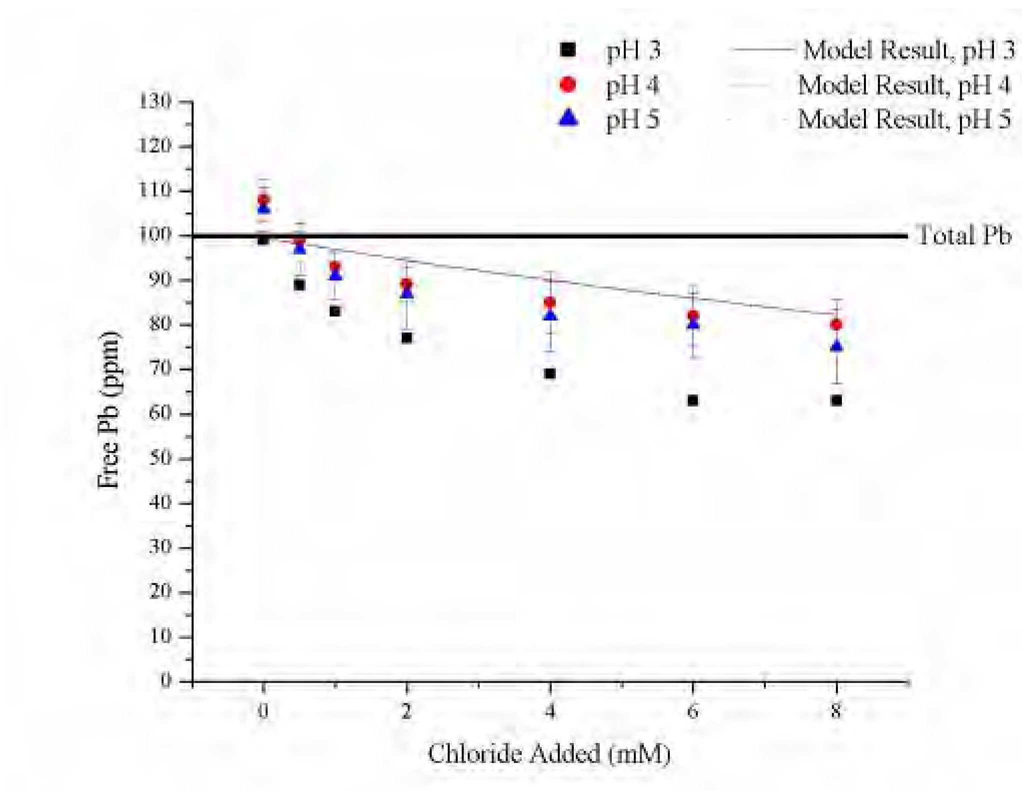


Figure 1.6 Effect of Chloride Addition on Free (Uncomplexed) Lead

Practically, when chloride complexes with lead to form soluble complexes, then the ultimate soluble lead in the water increases. Although previous studies that considered bulk water conditions of pH and Cl^- rightly determined these complexes were insignificant under normal circumstances, this work demonstrates that they can be highly significant in the thin layer of water near the lead pipe or solder during galvanic corrosion because the pH drops and Cl^- is concentrated. Considering the equilibrium equation: $Pb \rightarrow Pb^{2+} + 2e^-$, when the free lead ($Pb^{2+}$) decreases in the water as Pb^{2+} becomes complexed with chloride, then at equilibrium lead metal would corrode to form more Pb^{2+}. This cycle continues, and soluble lead increases, where soluble lead includes Pb^{2+}, $PbCl^+$, and other soluble complexes.

Effect of CSMR – Utility I, MD

Overall Summary

In the first 8 weeks of the study, for both brass and solder-copper couples, lead leaching was very high in all cases in the test rig. This is probably because the CSMRs of all waters were above the critical threshold of 0.5–0.58 identified by other studies as triggering rapid galvanic corrosion (Table 1.3). The raw water CSMR was around 5 (24 mg/L Cl^- ÷ 5 mg/L SO_4^{2-}). After alum coagulation followed by sedimentation and filtration, the CSMR was approximately 1.3 while the CSMR was around 5.3 after the PACl treatment (Table 1.3). Lead leaching from lead solder was significantly higher for the projected future condition simulating higher Cl^- from road salt.

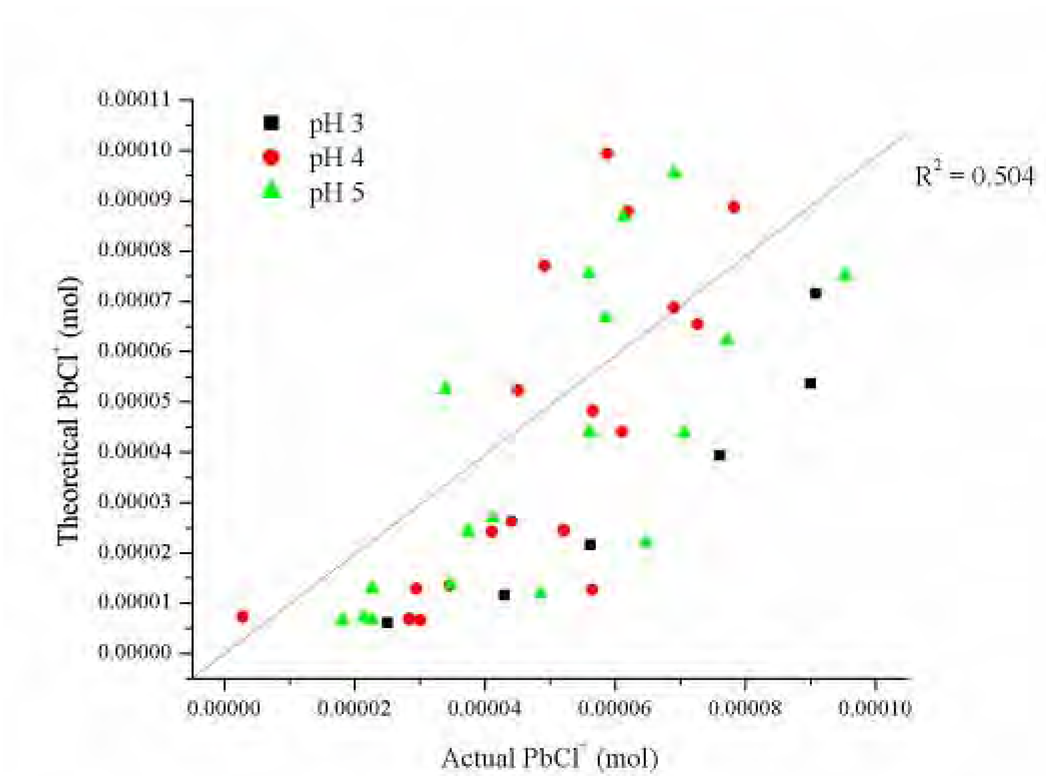


Figure 1.7 Calculation of the Formation Constant for $PbCl^+$

Brass

For the amount of brass and the volume of water in each glass vial, the lead concentrations were consistently below 15 ppb for all water conditions (Figure 1.8). A slight trend of increasing lead with increasing CSMR from brass was observed when the water was chloraminated (Figure 1.9). However, differences in lead concentrations were not statistically significant, and the 90% confidence intervals overlapped for all conditions.

Solder-Copper Couples

Lead in water. The lead concentrations measured in the solder-copper couples remained very high (>2,000 ppb) throughout the 8-week duration of the first part of work (Figure 1.10). Even the very high dose of orthophosphate inhibitor (1 ppm P) applied to all water conditions did not protect the solder-copper couples from corrosion. The apparatus was designed to maximize the geometric and physical conditions that are believed to contribute to lead solder corrosion caused by high CSMR, and the results demonstrate that success was achieved in this regard. Specifically, it was believed that localized low pH and high CSMR generated at the lead anode surface was the culprit for the persistent lead release, and the apparatus was designed to replicate and measure this worst-case scenario. In addition, the orientation of the lead solder at the bottom of the pipe is also believed to represent the worst-case scenario in real systems, since a build-up of chloride and other salts near the anode are suspected to prevent lead passivation, and this buildup would not be broken up by density gradients when the saline water is at the bottom.

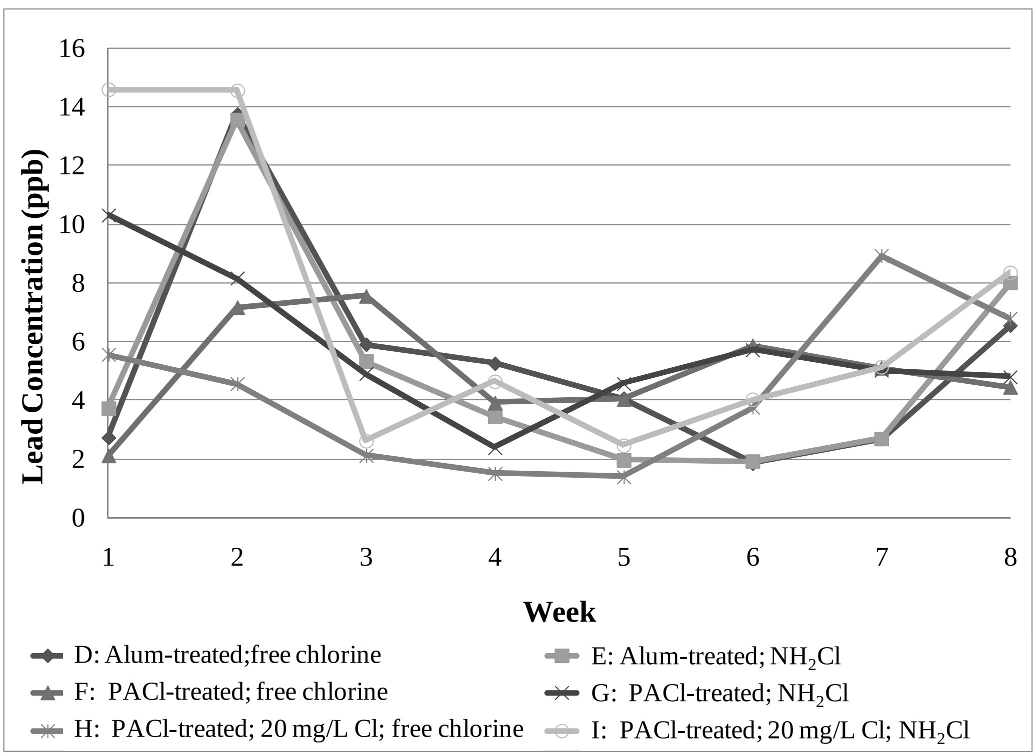


Figure 1.8 Lead released from brass during Part 1. No significant difference was observed among the water conditions for lead leaching from brass.

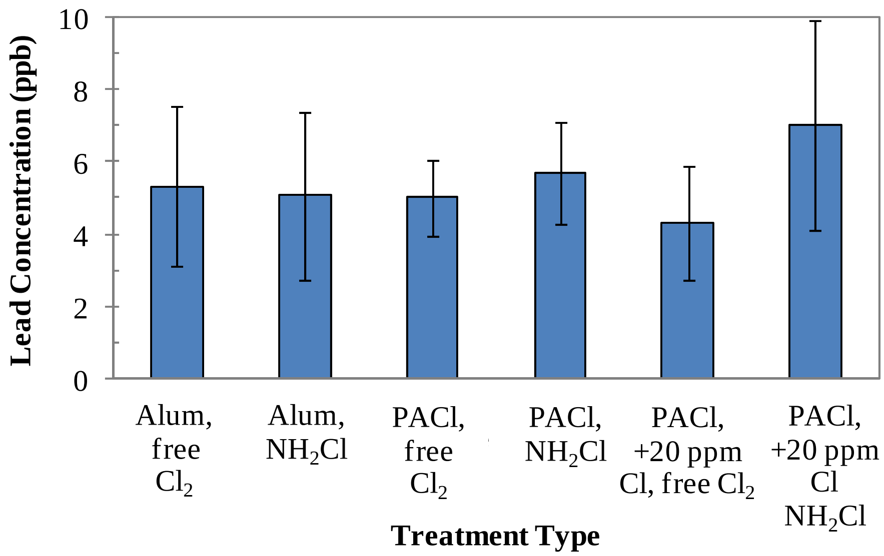


Figure 1.9 Average lead from brass with 90% confidence intervals during Part 1.

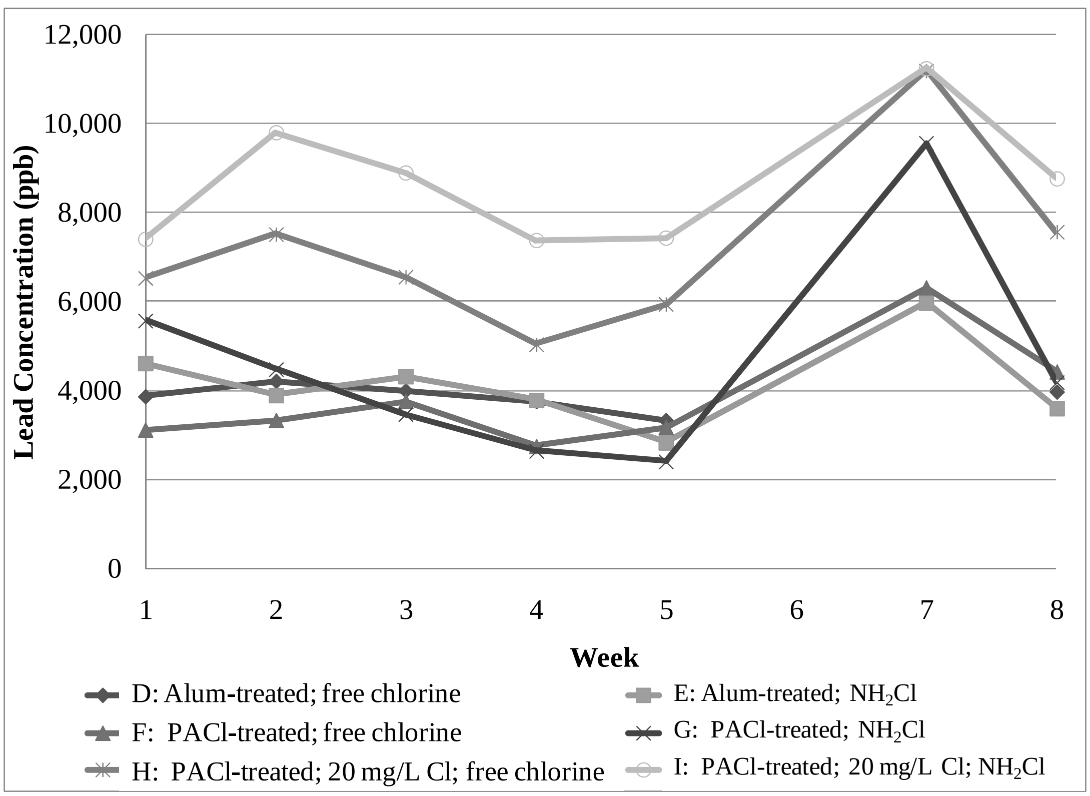


Figure 1.10 Lead released from solder-copper couples during Part 1. The alum- and PACl-treated waters behaved similarly, except when extra chloride was in the water (water types H and I). However, chloramines disinfectant appears to be more corrosive to the lead solder compared to free chlorine.

As expected, higher chloride in the water (PACl with additional 20 mg/L Cl) correlated with an increase in lead leached, which was on average two times higher than the other two conditions (Figure 1.11). However, variability in lead leaching was so high that no statistical difference was found between the waters in which only the coagulant was different (alum-treated versus PACl-treated waters). This may be explained by the relatively short duration of the test and the already high CSMR of the raw water and the finished water (CSMR>1 compared to the 0.58 referenced threshold ratio). A decision was made to continue the test for additional months to allow time to obtain confidence in key trends. On average, the CSMRs for alum- and PACl-treated waters were approximately 1.3 and 5.3, respectively, while the CSMR for the projected future condition with high Cl^- due to road salt was approximately 8.4 (Table 1.3). The peak observed during Week 7 is likely due to disturbance while taking pictures of the lead solder.

Galvanic measurements. The galvanic currents were measured for the solder-copper couples and were clearly related to the trends observed in lead levels (Figure 1.12). The galvanic current is a direct measure of the instantaneous rate of galvanic corrosion between the lead solder and the copper pipe. A higher magnitude of current indicates a higher rate of galvanic corrosion.

All of the values measured for this study were negative, which indicates the lead solder was being sacrificed and its corrosion was accelerated by connection to the copper. For instance, for the future watershed condition in which the CSMR was highest, the corrosion rate was 1.5 times higher than the rate for either alum- or PACl-treated waters without extra chloride (Figure 1.12). This is consistent with trends from Figure 1.11 in which the future watershed condition had about twice the lead release compared to either alum- or PACl-treated waters. The common trends between the real-time current measurements and the lead levels demonstrate that currents are relatively accurate indicators of corrosion and lead leaching was largely galvanically driven. For instance, for the future watershed condition in which the CSMR was highest, the corrosion rate was 1.5 times higher than the rate for either alum- or PACl-treated waters without extra chloride (Figure 1.12). This is consistent with trends from Figure 1.11 in which the future watershed condition had about twice the lead release compared to either alum- or PACl-treated waters. In addition, the observed trend throughout the study was that the galvanic currents decreased between water changes, most likely due to the dissipation of the oxidizing disinfectant. In the redox reaction, the electrons produced at the leaded surface (anode) are consumed at the copper pipe surface (cathode) by the reactions depicted in Figure 1.1.

Role of Disinfectants on Lead Corrosion

Brass

In general, chloramines appeared to be slightly more aggressive than free chlorine for brass. However, similar to the effects of CSMR, the differences were not statistically significant in the first part of study (Figure 1.9).

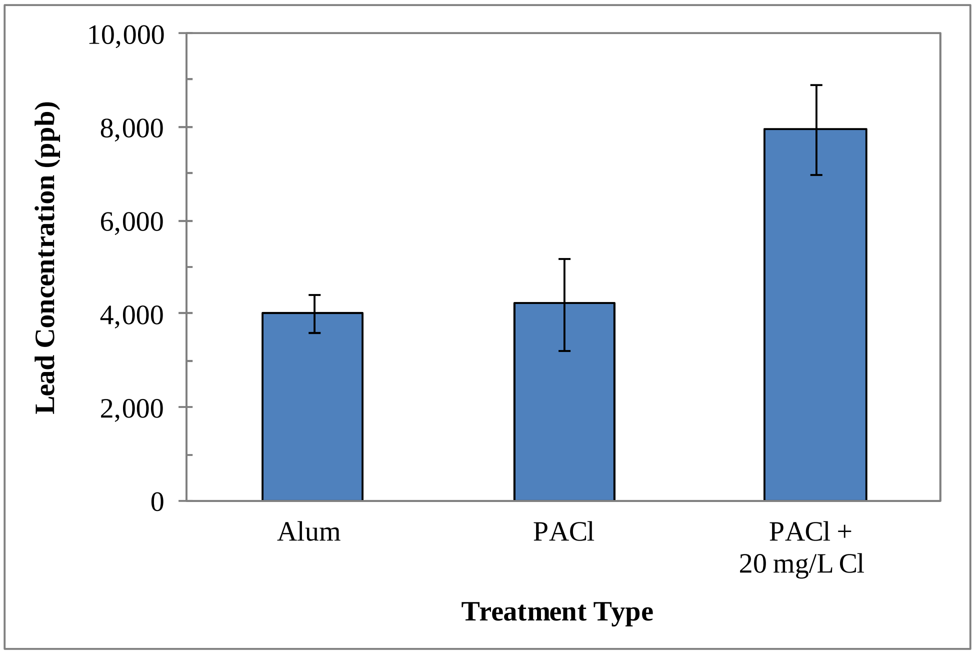


Figure 1.11 Average lead released in Part 1 from solder for the three CSMR levels. Increasing CSMR of alum (CSMR of 1.3), PACl (CSMR of 5.3), and PACl + 20 mg/L Cl (CSMR of 8.4) had similar amounts of lead released to the water, except in the case with the highest CSMR. Data from free chlorine and chloramines waters were averaged to obtain the comparisons in this figure. The error bars indicate the 90% confidence intervals.

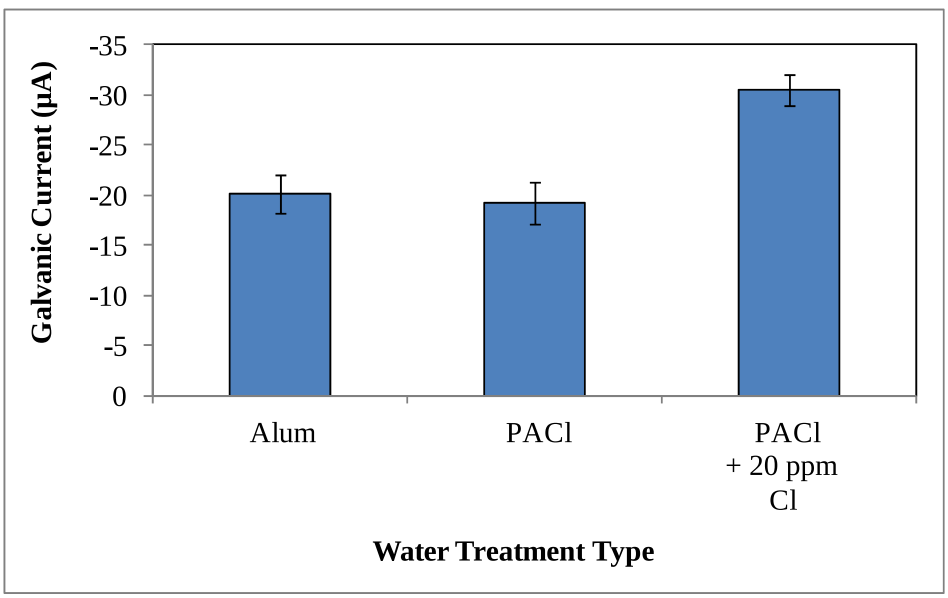


Figure 1.12 Average galvanic currents for each CSMR condition in Part 1. Each condition is an average of all measurements performed at least monthly for chlorine and chloramines disinfectants at each CSMR level. Similar to the lead levels in Figure 6, the future watershed condition (highest CSMR) was significantly greater than the other treatment types.

Solder-Copper Couples

Generally, chloramines were somewhat more aggressive than free chlorine regardless of the coagulant used for treatment. For example, the PACl-treated water with chloramines released an average of 6,300 ppb Pb while the same water but with free chlorine released 4,200 ppb Pb, which is a 30% difference (Figure 1.13). The average CSMRs of the PACl-treated water with free chlorine and chloramines were 5.3. The disinfectant had more impact on the PACl-treated water in projected future conditions with additional chloride—in that case, the water with monochloramine leached approximately 50% more lead than the water with free chlorine. The alum-treated water was not as impacted by the disinfectant type because nearly the same amount of lead was released in the presence of either free chlorine (3,800 ppb Pb) or monochloramine (4,400 ppb Pb). This result is consistent with the theory that sulfates (ex., from aluminum sulfate) in water protect lead from potentially corrosive conditions. Statistical analyses for the last three weeks of Part 1 before alkalinity or pipe orientation changes suggested that chloramines was more aggressive than free chlorine for PACl-treated water (p-value < 0.13) and PACl-treated water with road salts (p-value < 0.10). Due to the variability of corrosion, a p-value (p) below 15% or 0.15 was chosen for this study to indicate statistical confidence that results were different.

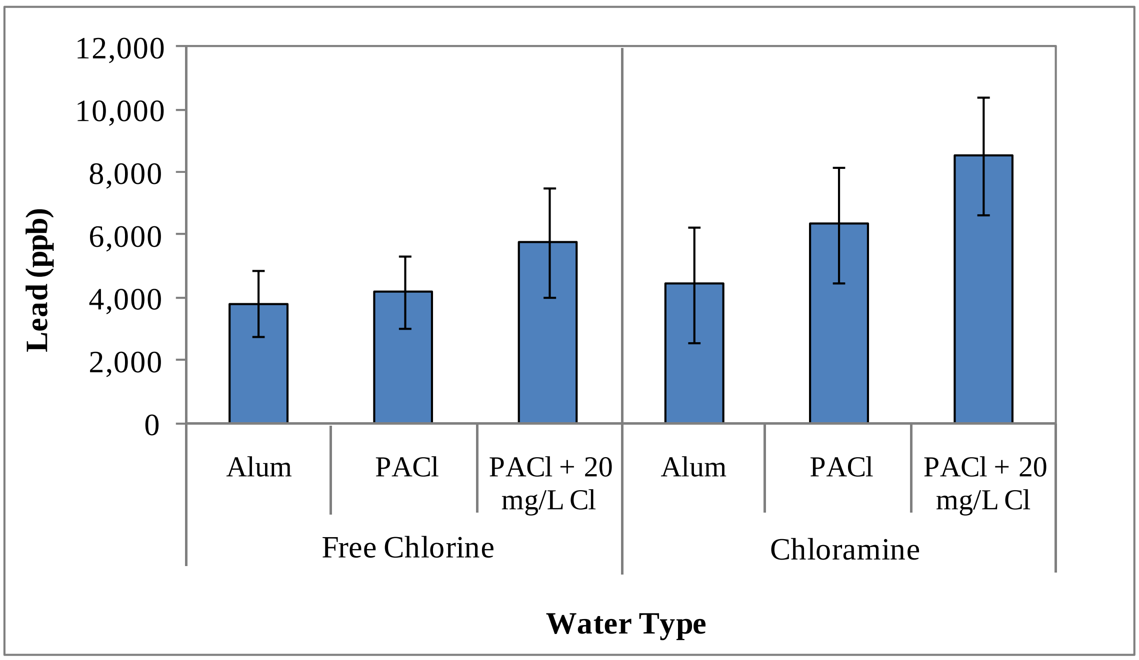


Figure 1.13 Average lead released during Weeks 6 through 8 from solder. Lead levels were slightly increased by chloramines disinfectant for PACl-treated water (p-values of 0.13 and 0.10 for PACl and future watershed conditions, respectively). The 90% confidence intervals are shown.

Galvanic current measurements were consistent with lead data from Figure 1.13. Both types of measurements, lead concentrations and galvanic currents, indicate that the future water condition could have more lead corrosion with chloramines than with free chlorine ($p < 0.02$).

The effect of the disinfectant was not as obvious based on the currents for the alum-treated or PACl-treated water (Figure 1.14).

Part 2: Long-Term Trends and Effects of Alkalinity and Solder Orientation

Long-term Trends

After completing the work described in the original Water Research Foundation RFP, extra testing was performed to examine other conditions and to obtain greater confidence in key trends. One replicate for each of the six water conditions was continued with no water quality changes in the second part of this study.

The main observed trend was that the alum-treated water had dramatic decreases in lead levels compared to the PACl-treated waters, with the exception of the chloraminated PACl-treated water. Three of the four PACl-treated waters had the same amount of lead release throughout the second part of the work (Figure 1.15). In fact, the future water quality condition with road salts and either chlorine or chloramines disinfection increased at least 30% during Part 2 (Figure 1.16). The alum-treated water conditions with chlorine or chloramines had at least a 90% decrease in lead release. For example, alum with free chlorine decreased from approximately 1,000 ppb down to 70 ppb while alum with chloramines decreased from 4,200 ppb to 140 ppb (Figure 1.16). The PACl-treated water with chloramines had an 80% decrease in lead from approximately 1,300 ppb to 260 ppb (Figure 1.16). With enough time, it is possible that all water conditions would have much lower lead levels, but decreases did not occur during the 4.5-month duration of this study for the future water condition with road salts and PACl-treated water with free chlorine.

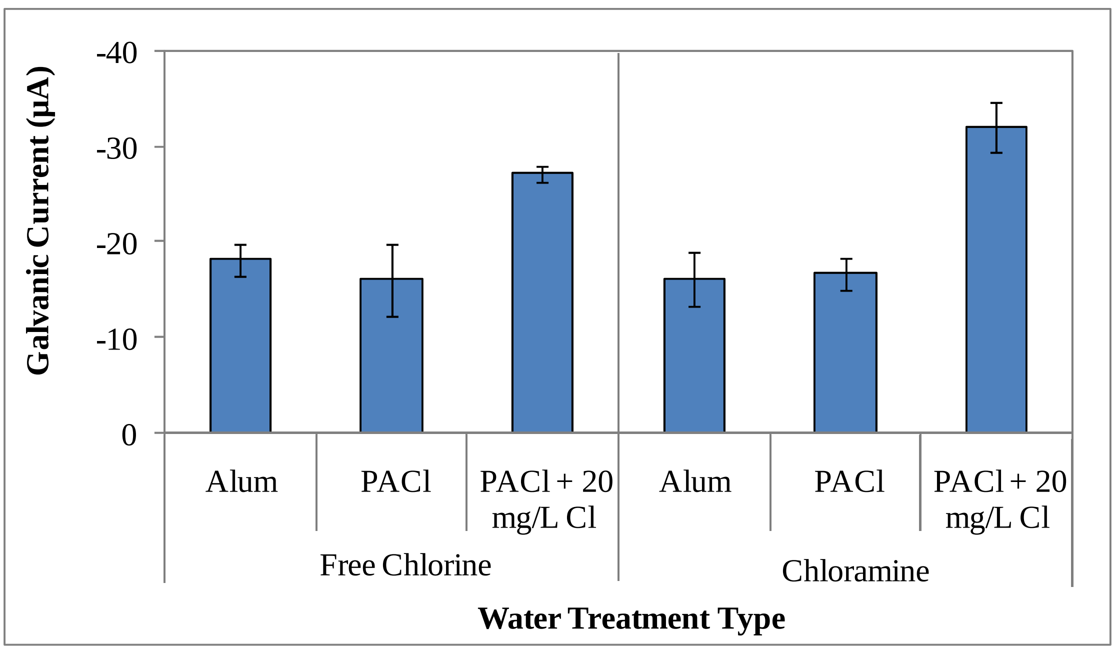


Figure 1.14 Average galvanic currents during Weeks 6 through 8 from solder. The current measurements are consistent with the trends in lead release in Figure 1.13. The 90% confidence intervals are shown.

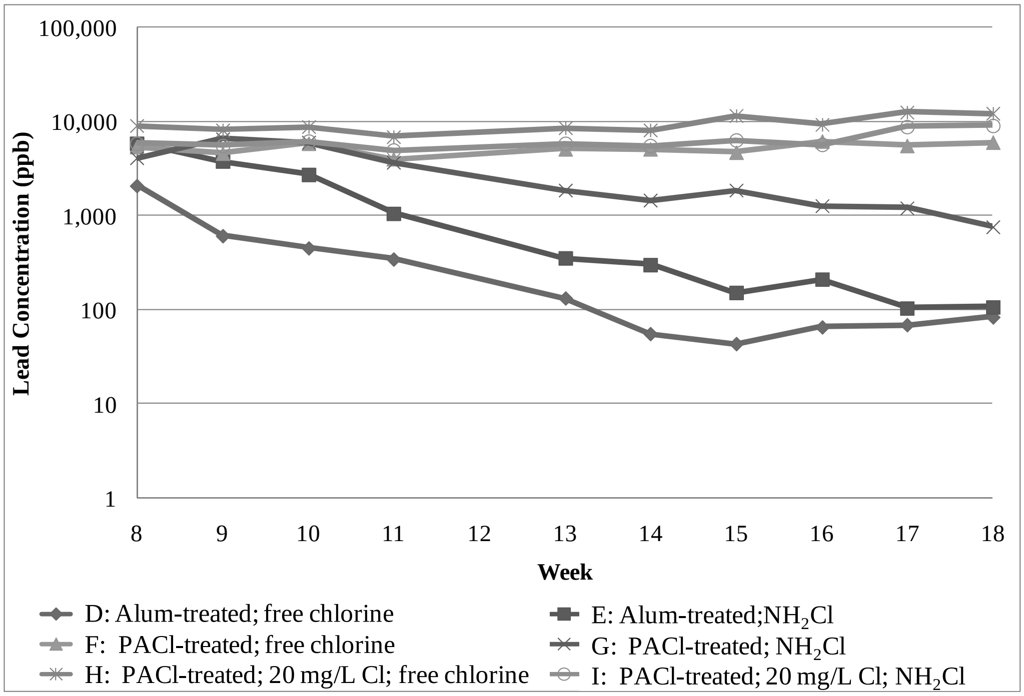


Figure 1.15 Lead concentration of water in the solder-copper couples during Part 2 for the control conditions. The replicate in which this data summarizes is for the replicate condition where no alkalinity or pipe orientation adjustments were performed. For most of the PACl conditions, the lead levels remained the same throughout the experimental run. The alum-treated waters had dramatic decreases in lead over time.

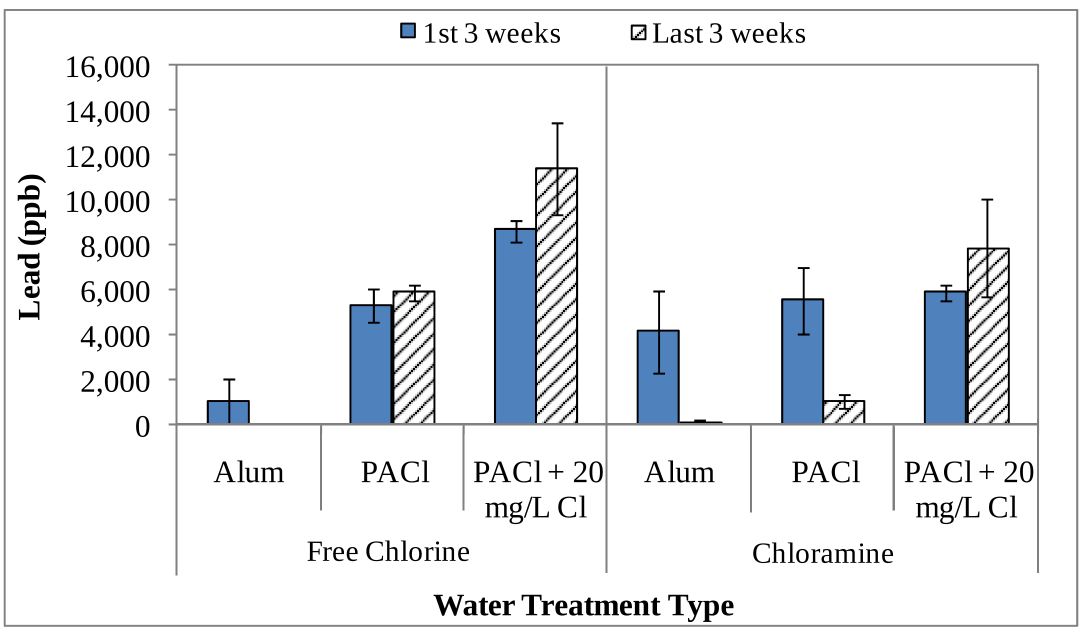


Figure 1.16 Average lead during the first and last three weeks of Part 2 for the control conditions. Alum-treated waters had significant decreases in lead levels during the second part of the work while three of the four PACl conditions had lead levels that did not change or even increased.

Effect of Alkalinity

One of the objectives for Part 2 was to determine if higher alkalinity could reduce lead release. Low pH occurs at the lead solder metal surface because of corrosion reactions; however, increased alkalinity provides pH buffering that prevents the low pH and the dissolution of metals such as lead into the water. When possible, the replicate for each of the six water conditions that was thought to have the highest lead level was altered in Part 2 to have high alkalinity (100 mg/L as $CaCO_3$ compared to 25 mg/L as $CaCO_3$) at Week 9. As a result, benefits of higher alkalinity were tested on the "worst case" test rig.

Additionally, during Part 2 solder orientation was evaluated. Copper joint failures in the field have suggested that corrosive attack on solder may be worst when solder is at the bottom of the joint. To investigate this theory, the solder was located at the bottom of the pipe until Week 8, and then at Week 9 one solder-copper replicate from each of the six water treatment types was oriented upside down. The lead levels, local pH measurements, and galvanic currents were then compared during the second part of the study.

At Week 8 before alkalinity and pipe orientation changes, the average lead release for the control pipe was approximately 5,400 ppb Pb for all three conditions (Figure 1.17). The data from Week 8 ("before"), which is summarized in Figure 1.13, includes the average of six data points for Week 8 for each of the three conditions – control, high alkalinity, and inverted pipe. The "after" data consists of averages of the lead data from the last 9 weeks of the experiment.

Between weeks 9 through 18, the lead levels dropped an average of 20% or more for all three conditions including the control (Figure 1.17). An even greater drop of 70% occurred for

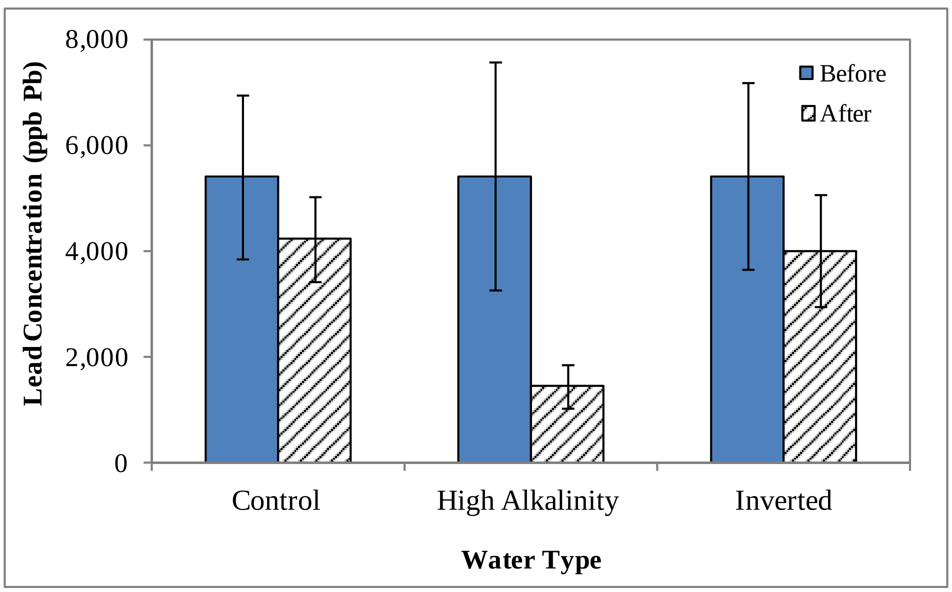


Figure 1.17 Average lead release before and after changes in alkalinity or pipe orientation. Each condition had lead level decreases of at least 20% over 10 weeks; however, the higher alkalinity conditions had decreases of approximately 70%. The "before" data were averages of all pipes destined to be the control, high alkalinity, or inverted conditions for week 8. The "after" data is the average lead levels for the same pipes from weeks 9-18. The error bars represent the 90% confidence intervals.

the higher alkalinity conditions between weeks 9 through 18 (Figure 1.17). Furthermore, the galvanic current measurements also subsided along with the lead levels. The currents for the high alkalinity condition decreased from an average of -23 µA to -9 µA, which is a 60% decrease (Figure 1.18). The control conditions and inverted pipes only decreased from around -20 µA to -15 µA and -12 µA, respectively, which equates to a 25% and 40% decline. Thus, substantial benefits were attributed to higher alkalinity in preventing this type of lead corrosion.

An explanation for the observed decrease in lead corrosion in the high alkalinity conditions is that while lower pH occurred at the lead anode surface for the control conditions, pH buffering due to alkalinity prohibited acidic conditions. Hence, the dissolution of metals such as lead into the water was reduced. In fact, in the high alkalinity waters, the pH ranged between 6.8 and 8.5 throughout the depth of the copper pipe and at the solder surface. In contrast, the pH near the bottom of the solder in the low alkalinity control conditions plummeted sharply to pH 5.0 and was measured to be as low as pH 3.3 throughout the study (Figure 1.19). Buffering clearly helped to prevent development of this adverse local condition.

The declining lead levels over time for higher alkalinity were especially apparent for the higher CSMR conditions when PACl treatment was used. For the control conditions, where the solder orientation and water quality was unchanged from Part 1 of the study, the alum-treated waters exhibited decreases in lead throughout Part 2 of the study (Figure 1.20). However, the PACl control conditions, except for PACl with chloramines, remained at the same lead levels throughout (>3,600 ppb lead). In contrast, the lead concentrations measured in the waters with high alkalinity decreased from Week 8 to Week 18. For instance, the future higher Cl^- watershed condition with chloramines disinfectant, which was one of the most corrosive waters in the control set, decreased from 10,400 ppb to 2,900 ppb lead (Figure 1.20).

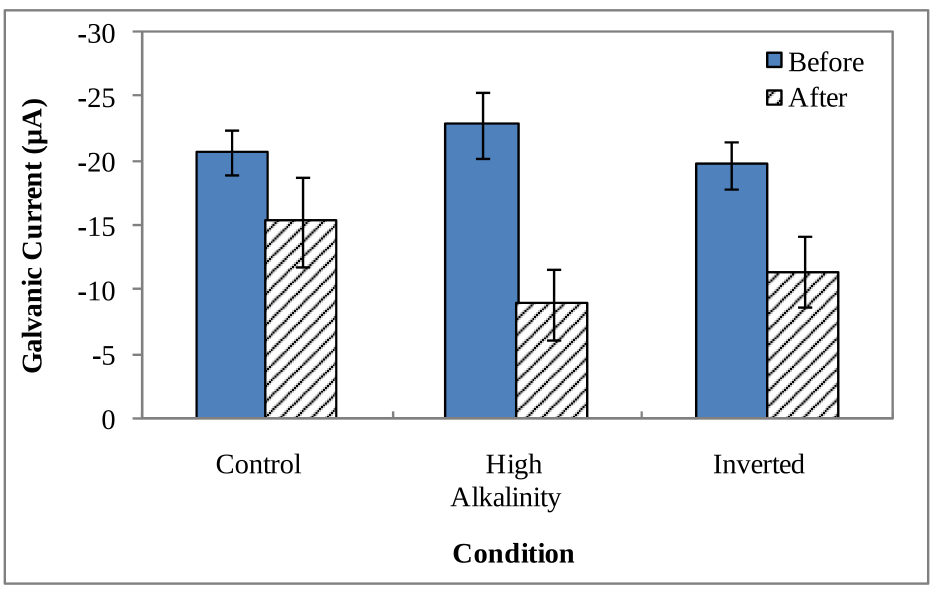


Figure 1.18 Average galvanic currents for the solder-copper couples before and after alkalinity or solder orientation changes. The currents were consistent with the trends from the lead levels in the water. The greatest drop was from the high alkalinity conditions, followed by the inverted pipes and the control conditions.

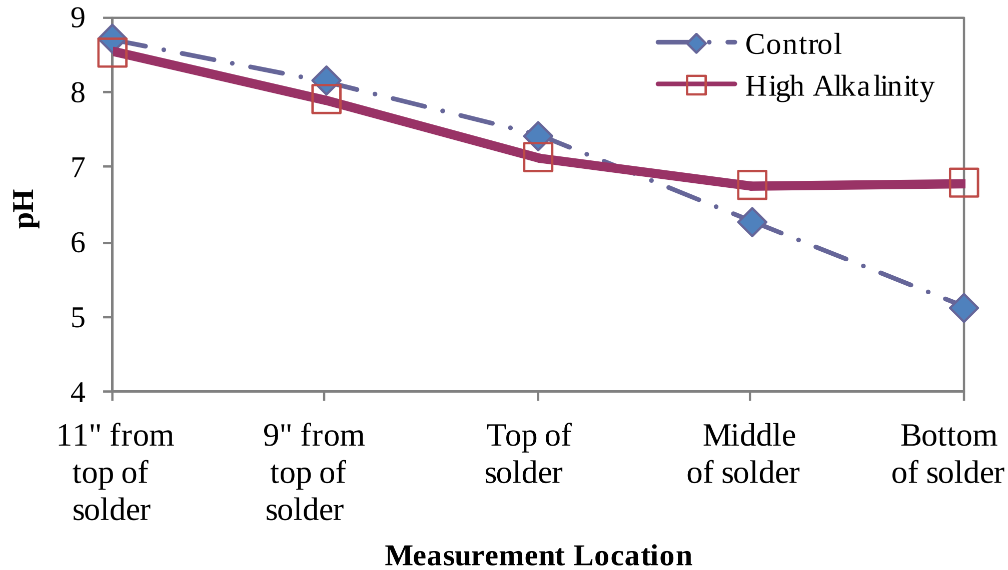


Figure 1.19 pH along the profile of the solder-copper couple in Part 2 of study. See Figure 1.2 for identification of measurement locations. A pH gradient between pH 8.5 and 5.0 was measured with depth in the control pipes.

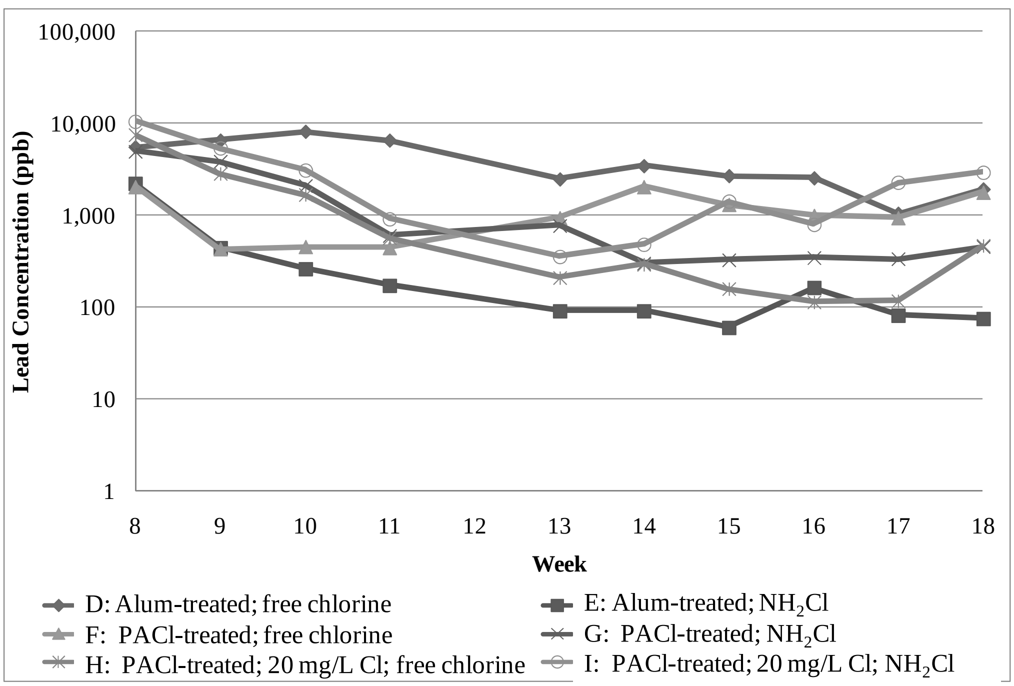


Figure 1.20 Lead release from the solder-copper couples during Part 2 for the high alkalinity conditions. For all conditions, the lead levels decreased from Week 8 to Week 18. The alum-treated waters had dramatic decreases in lead over time.

For all but one condition, the high alkalinity waters had lower lead levels than the low alkalinity conditions during the last 5 weeks of the study (Figure 1.21). The exception was the solder-copper connection exposed to alum-treated water and free chlorine, which was shown to be the least aggressive condition in this study. This particular replicate consistently had one of the highest lead levels throughout the study, and the entire wire corroded completely at the solder-silicone interface at the end of the study. This is an example of the variability of corrosion and indicates the importance of replicate samples to provide a representative picture. The attack on this wire also illustrates how devastating galvanically driven lead corrosion can be.

Effect of Solder Orientation

At the surface of the lead material, salts such as H^+, Cl^-, and SO_4^{-2} are present at very high concentrations. Salt water has a higher density than water with less salt, so if the water with concentrated salts is ever on top of bulk water with dilute salts, the difference in density will induce natural mixing (Figure 1.22). In contrast, if the water with concentrated salts is ever below the less dense water with dilute salts, the system is stable and resists mixing.

To the extent mixing of water near the anode occurred with the bulk water, the lower pH and high level of Cl- at the anode would decrease, similar to what would occur if the water was not stagnant. So if the solder were ever at the top of the pipe (unlikely due to the fact it flows with gravity), the impacts of CSMR would be less severe.

Lead release. In terms of lead leaching, the inverted pipes with solder located at the top of the copper pipe had similar lead levels as the control conditions, where the only difference was that the solder was located at the bottom of the pipe (Figure 1.23). Similar to the control conditions, the inverted pipes had lead levels that averaged 5,400 ppb Pb before the orientation change but then decreased to an average of 4,000 ppb Pb after the change while the control had an average of 4,200 ppb Pb at the same period (Figure 1.17). Furthermore, statistical analysis demonstrated that the inverted condition was not statistically different from the control ($p = 0.79$). For most of the second part of study, the lead concentrations in the water decreased but increased during the last three weeks for unknown reasons (Figure 1.24).

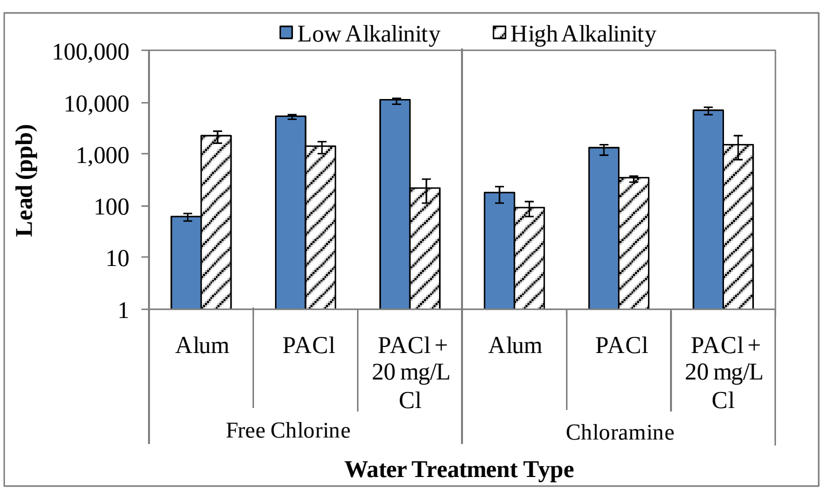


Figure 1.21 Average lead during the last 5 weeks for the low alkalinity (control) and high alkalinity conditions. For 5 out of 6 cases, the higher alkalinity water had lower lead levels than the low alkalinity waters.

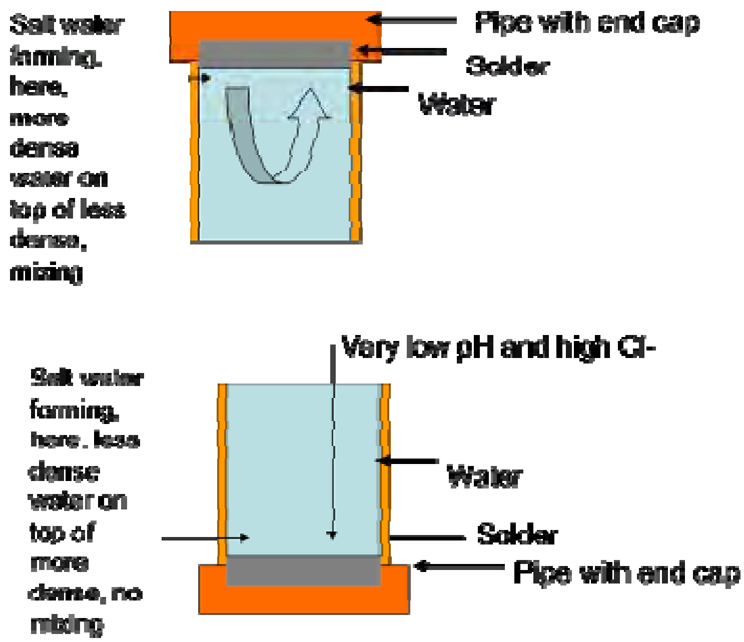


Figure 1.22 Diagram of effect of solder orientation in pipe

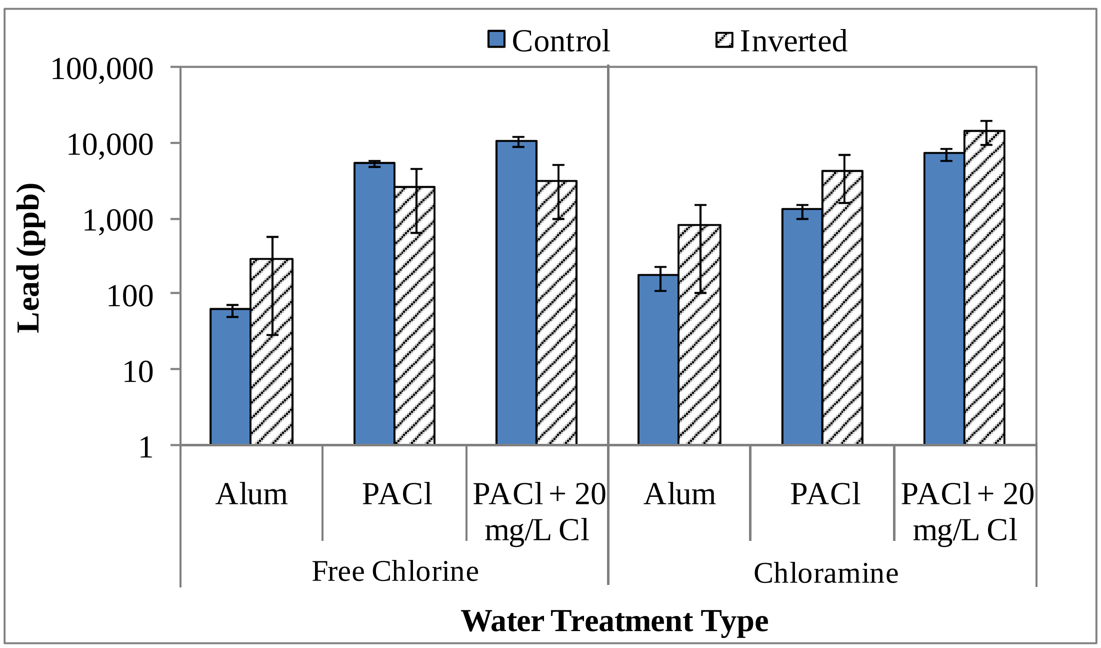


Figure 1.23 Average lead during the last 5 weeks for the control and inverted solder-copper couples. The lead levels in the inverted pipes were similar to the levels in the controls in this short-term study.

Galvanic measurements. The galvanic currents or real-time corrosion rates were slightly lower than the rates for the control conditions but were considered statistically different with a p-value of 0.15 (Figure 1.18). While the control conditions had a high corrosion rate of -15 µA, the inverted pipes had lower currents that averaged -11 µA. Prior to Part 2, the currents were

statistically the same (p = 0.68). The explanation is that internal mixing occurred within the pipe as the dense lead and salts settled from the solder at the top to the bottom of the apparatus. The conclusion is that inverting the pipe lessened galvanic corrosion markedly but did not dramatically reduce lead leaching in the short-term. It is expected that benefits would have occurred in the long term. This result has practical relevance in that solder connected to copper at the bottom of the pipe is more prone to problems from this type of corrosion than solder connected to copper at the top of a pipe.

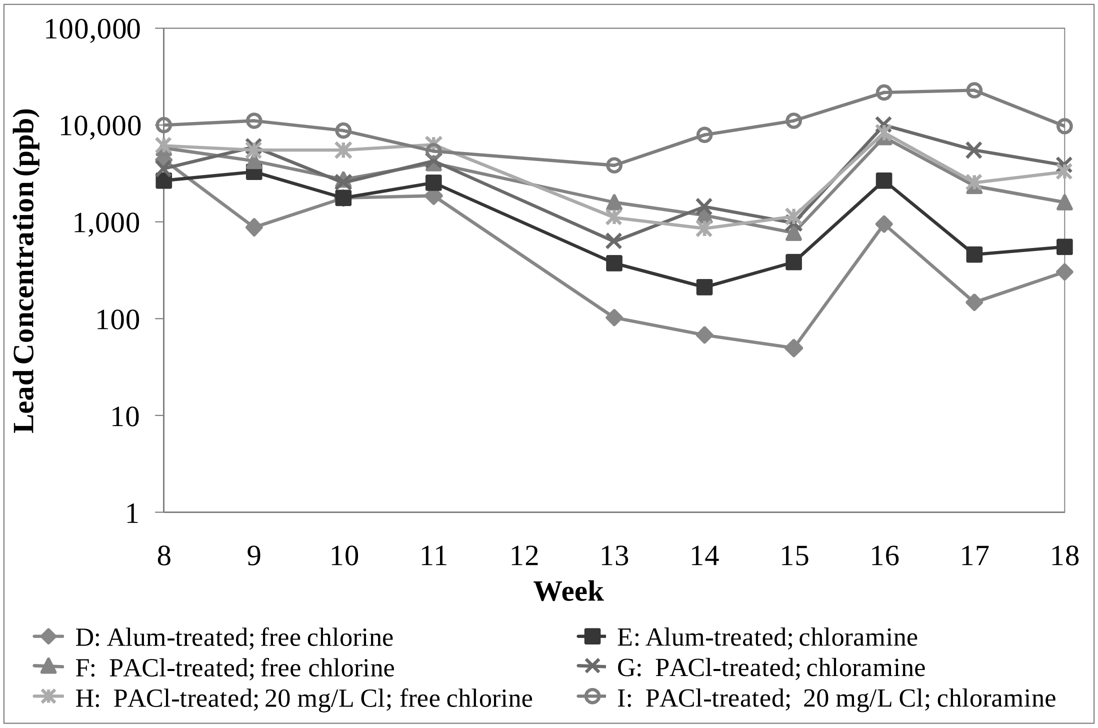


Figure 1.24 Lead in water during Part 2 for the inverted solder-copper couples. The lead levels were similar to the levels in the controls and declined for the majority of the second part of the work.

Mechanistic Insight in Lead Corrosion: Local Measurements

The worsened corrosion of lead solder at higher CSMR is explained by the localized high chloride and low pH near the lead surface. Previous research has shown that sulfate is very effective in forming insoluble lead sulfate solids at pHs as low as pH 3. As a result, the precipitated lead sulfates form a protective layer around the leaded metal, thereby explaining benefits from sulfate in water. Chloride at the low pHs near the lead solder anode can form soluble complexes with lead. This explains why chloride is detrimental to lead and can increase lead leaching. Additionally, the concentration of salt at the bottom of the pipe indicates that internal mixing could be a factor in limiting corrosion, if the solder is located at the top of the pipe. The localized corrosive attack was visible (Figure A.1) and even resulted in solder wire being corroded through (Figure A.2).

Chloride and Sulfate

Localized chloride micro-measurements throughout the depth in the solder-copper pipe couples were performed periodically during Part 1 of the Utility I case study. The chloride concentration tended to be higher toward the bottom of the pipe and at the solder surface (Figure 1.25). The trend was most apparent in the water with additional chloride. A salt water layer was essentially formed near the lead at the bottom of the pipe near the silicone stopper. For example, the chloride concentration at the very bottom of the pipe was as much as 10 times the concentration at the top of the copper pipe when free chlorine was present. This is expected based on the galvanic cell reactions depicted in Figure 1.12. The concentration of chloride and the high effective CSMR at the bottom of the pipe could explain the large amounts of lead released from the solder. This supports the hypothesis that chloride migration and build-up near the lead anode is a contributing factor in lead release for high CSMR waters.

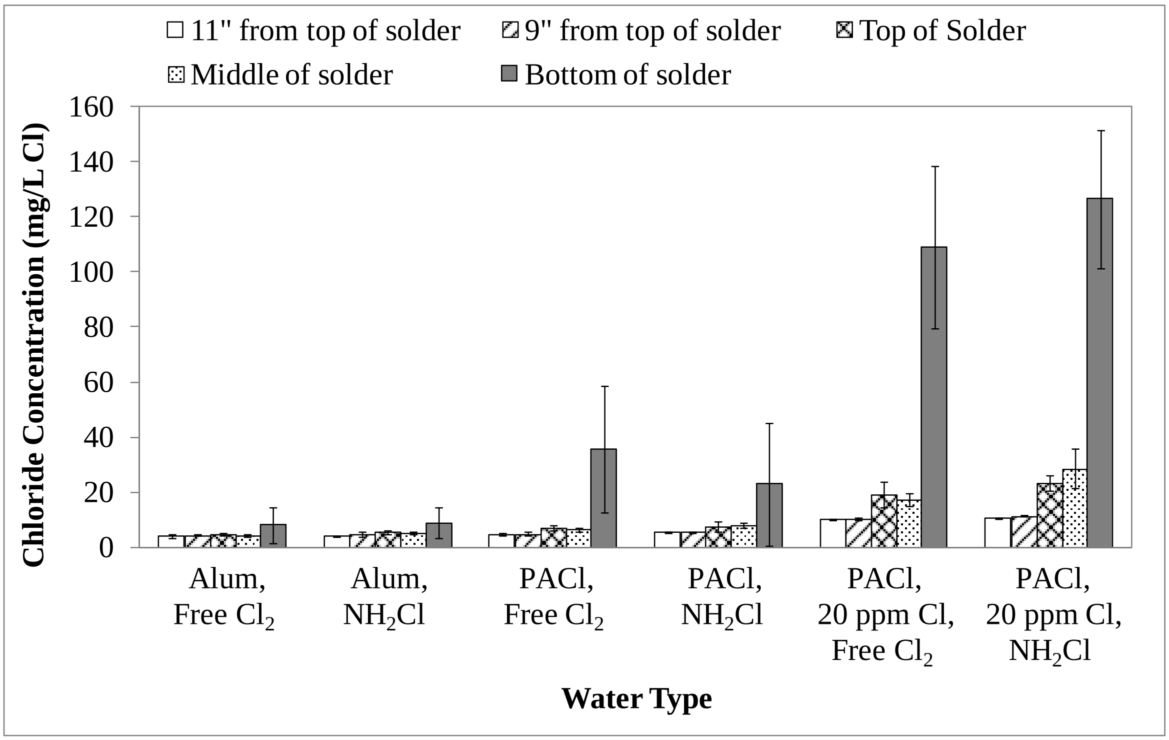


Figure 1.25 Chloride concentration along the profile of the solder-copper couples measured with a microelectrode. The chloride concentration increased toward the bottom of the pipe. The error bars represent the 90% confidence interval.

ICP-MS analysis of water sampled in the top and bottom of the ¾" copper pipe and ½" pipe, respectively, further indicated a buildup of high chloride and sulfate concentrations at the bottom of the pipe near the solder (Figure 1.26). The sulfate concentration was consistently approximately two times higher at the bottom than at the top of the pipe. The chloride concentration was also higher at the bottom than at the top, but a higher ratio of the chloride residing at the bottom was measured for the higher CSMR conditions. The CSMR was measured to be as high as 10.8 for one of the future watershed condition replicates with chloramines when

the overall CSMR was approximately 8.4. The disinfectant type appeared to have no effect on the distribution of chloride and sulfate. The chloride and sulfate anion concentrations confirm reactions shown in Figure 1.12 in which anions migrate toward the anode. In this case, the anode is the lead solder, and measurements support that the anion concentrations were higher at the bottom where the solder was located.

pH Measurements

Throughout Part 1 of the study and for the control conditions in Part 2, the pH decreased (i.e., was more acidic) toward the bottom of the pipe where the solder was located, consistent with expectations for reactions near the anode (Figure 1.12). The initial bulk water pH was 7.7±0.1, but the pH at the top of the pipe was generally around pH 9, which is expected because the copper is the site of the cathodic reaction (Figure 1.27). During Part 1, the average pH at the bottom of the solder-copper couple was pH 5 but was measured to be as low as pH 3.9 for individual solder-copper couples. When lead is connected to copper, the anodic and cathodic reactions are separated (Figure 1.12). The water near the lead-bearing material surface becomes acidic, whereas the cathodic reactions occur over the surface of the copper. In this situation, lead leaching to water could be increased by a higher corrosion rate and/or a lower pH at the surface of the leaded material. Since lower pH tends to prevent passive film formation on lead surfaces, high galvanic currents are somewhat self-perpetuating.

The pH was lowest at the anode for the treatment types with higher CSMR. For instance, the pH was 5.9 at the deepest point in the alum-treated water while the PACl-treated water had pHs as low as pH 5.0 (Figure 1.28). The future watershed condition, which has the highest CSMR, had an even lower average pH of 3.9 for the water contacting the solder. This further suggests the importance of low pH in conjunction with high chloride in accelerating lead release in galvanic corrosion reactions between copper pipe and lead solder. It also explains why even a high dose of orthophosphate cannot control lead corrosion since orthophosphate is only effective for lead down to about pH 5.0. The fact that the pH was so highly acidic demonstrates the desired mechanistic insight, even if some mixing occurred.

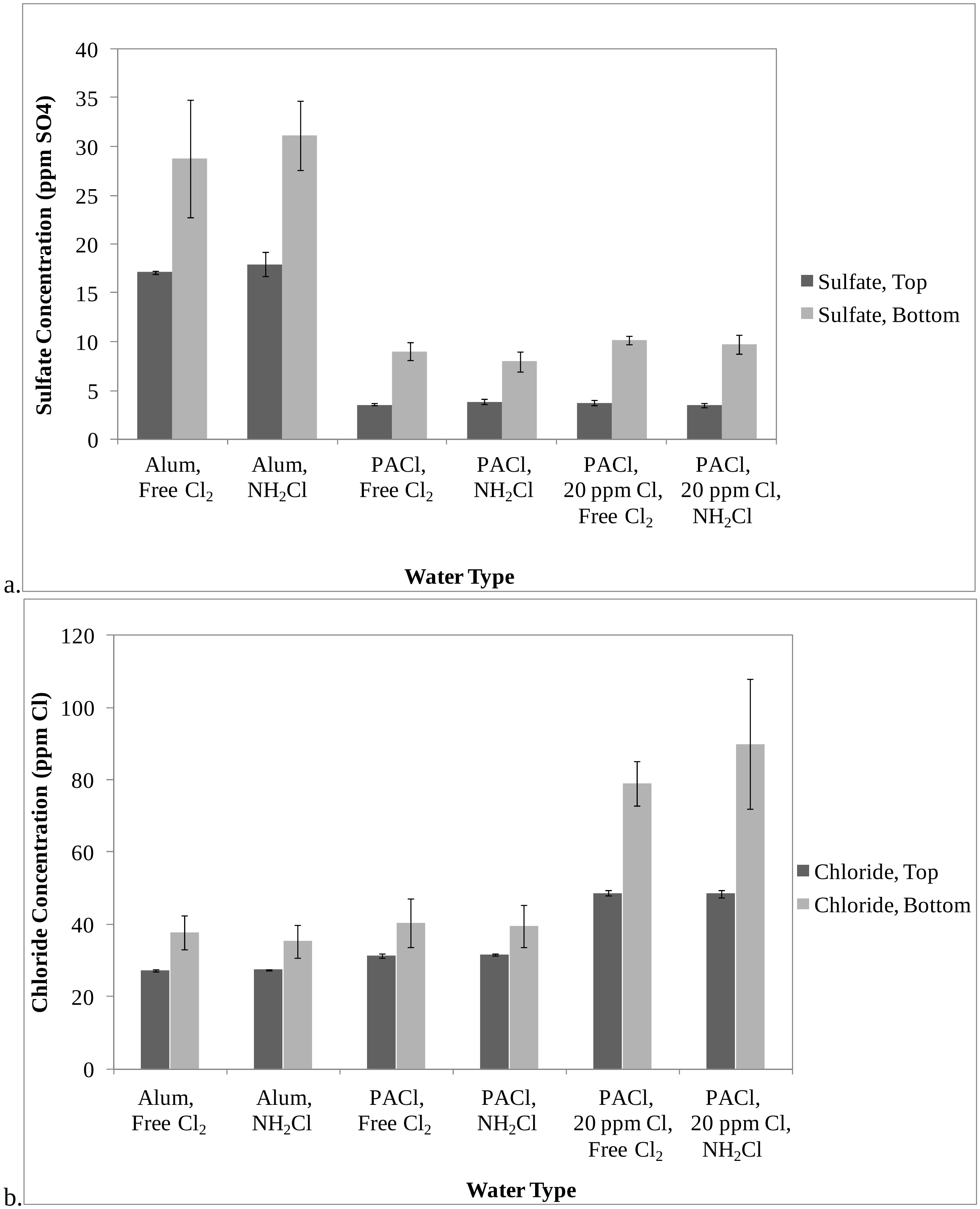


Figure 1.26(a-b) Sulfate and chloride concentrations at the top and toward the bottom of the pipe during Part 1. The sulfate (a) and chloride (b) anions had higher concentrations at the bottom of the pipe than at the top. Migration of anions to the anode is expected to occur and as diagramed in Figure 1.8.

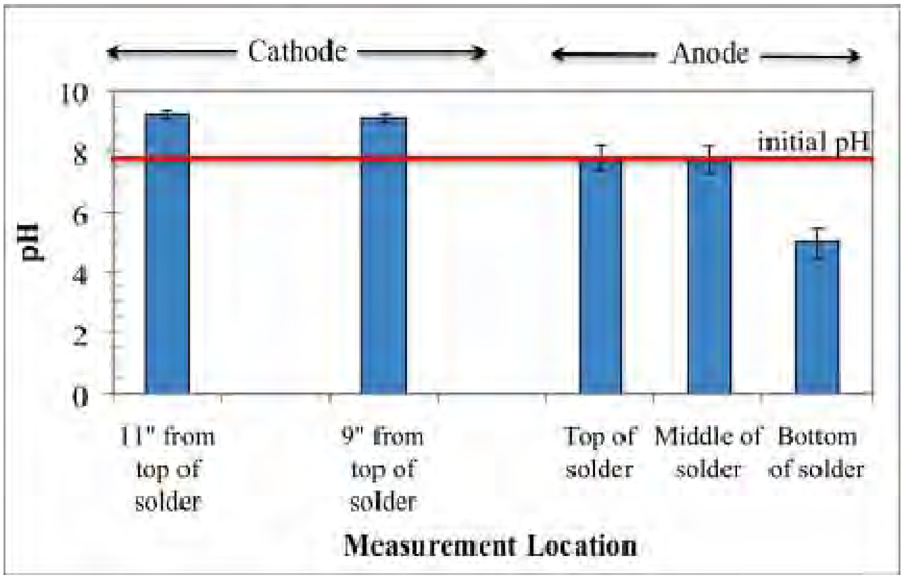


Figure 1.27 Average pH throughout the depth of the solder-copper pipe couples in Part 1. The pH increased at the top of the pipe from pH 7.7 and decreased to around pH 5 at the lowest point on the solder. The error bars represent the 90% confidence intervals.

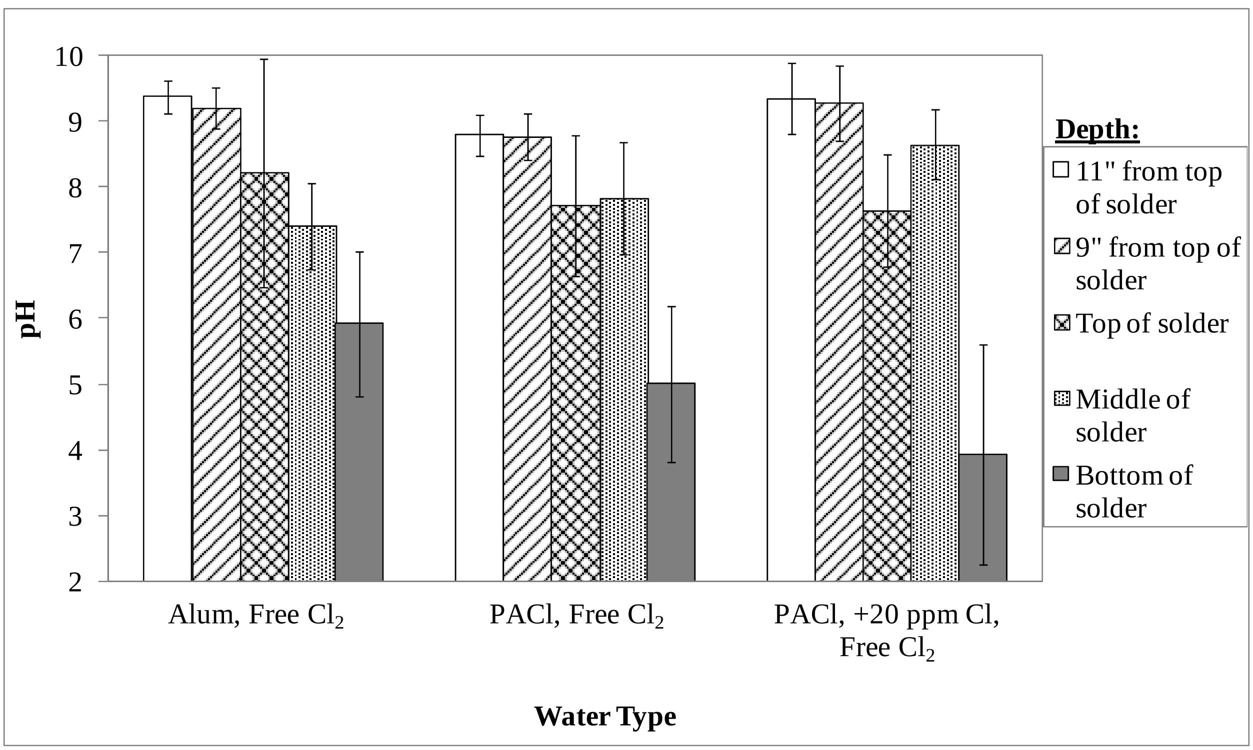


Figure 1.28 Average pH in solder-copper pipe couples for the three CSMR levels with free chlorine in Part 1. The general trend is that pH decreased with depth and with closer proximity to the solder. Lower pH was measured with increasing CSMR. The error bars represent the 90% confidence intervals.

Lead Concentrations at Top and Bottom

The entire volume of water in the smaller diameter copper pipe portion was analyzed for metals and compared to an aliquot of water from the top of the solder-copper couple during Part 1 of the study. The lead concentration at the bottom of the pipe was at least 85 times and as much as 250 times greater than the concentration in the upper section of the pipe (Figure 1.29). This is expected given the lack of mixing in the pipe, the lower pH in the bottom of the apparatus, and the proximity to the lead anode.

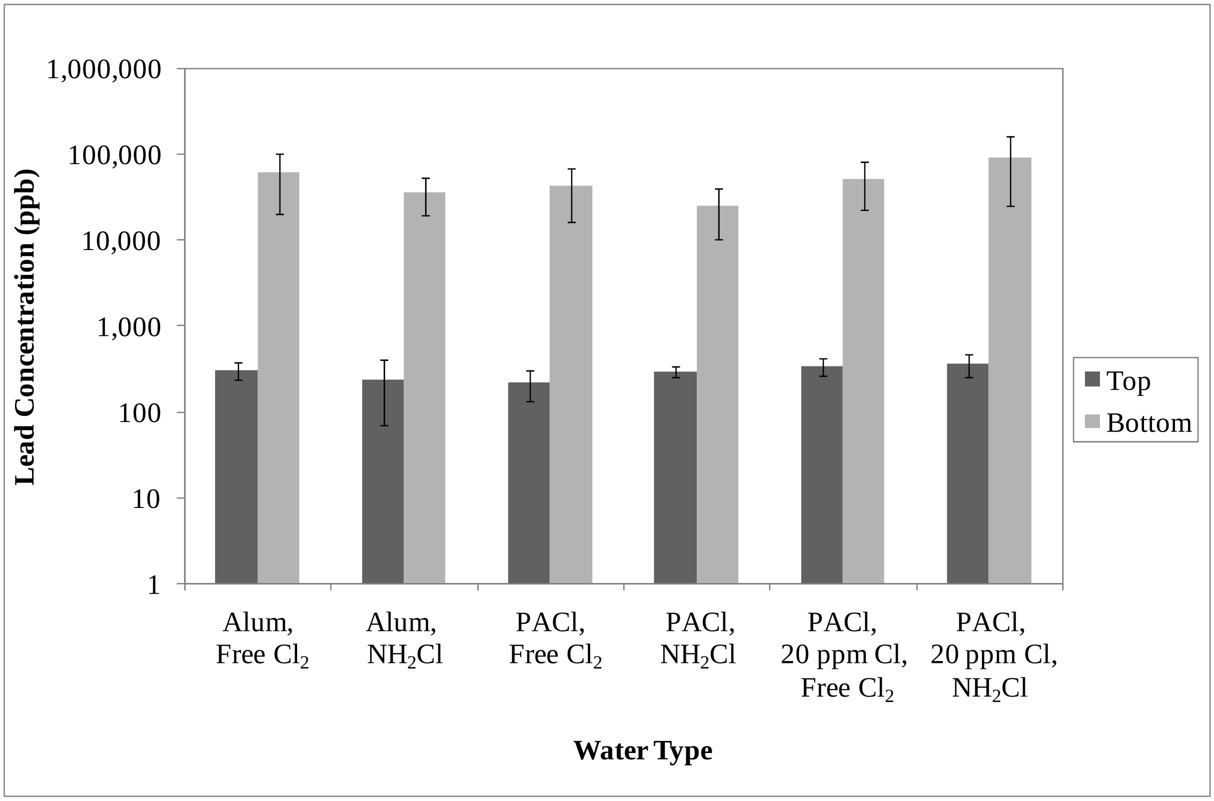


Figure 1.29 Lead concentrations at the top of the copper pipe and at the solder ("Bottom"). The concentration of lead is at least 85 times greater at the bottom of the pipe than at the top of the pipe. This is due to lead particles settling to the bottom of the vertical copper pipes. The dark bars represent the lead concentration at the top of the pipe and the light grey bars represent the lead concentration at the bottom of the pipe. The error bars are shown as 90% confidence intervals.

CONCLUSIONS

- At pH 3, pH 4, and pH 5, the concentration of soluble lead decreased with the addition of sulfate.
- Over the pH range of 3-5, changes in the pH had little effect on the solubility of lead sulfate.
- In the presence of sulfate, $PbSO_4$ formed with the solubility product constant (K_{sp}) value 1.54×10^{-8}, which is in very good agreement with accepted models.
- At pH 3, 4, and 5, the uncomplexed or free lead concentration decreased with the addition of chloride, presumably as a lead chloride complex formed.
- An optimized constant was calculated for the formation of $PbCl^{+}$ of K = 59.5, which is in the range of that previously reported, but indicates that chloride complexes are slightly more significant in lead solubility than was previously realized.
- From the Utility I case study:
    - For the conditions studied, brass leached very low levels of lead to the water.
    - Even with relatively high orthophosphate inhibitor dose, 50:50 Pb/Sn solder wires connected to copper pipes released very high amounts of lead to the water.
    - A combination of low pH and high CSMR at the solder surface drove the long-term galvanic corrosion of the leaded solder, as demonstrated by local measurements of chloride, sulfate, and lead near the anode.
    - Increased alkalinity in the water was very effective in mitigating the low pH at the lead solder anode and eventually causing decreased lead levels.
    - The effect of CSMR on lead leaching was not statistically significant in the comparison of the alum- and PACl-treated waters in the first part of the utility case study, due to already high CSMRs in all waters
    - However, the projected future watershed conditions with road salt, which had additional chloride in the water, had the highest amounts of lead released.
    - Overall, chloramines were more aggressive than free chlorine in lead corrosion for the current PACl-treated water conditions and the projected future watershed condition.
    - The lowest lead levels were observed for the alum-treated waters with either disinfectant and the PACl-treated water with free chlorine.

CHAPTER 2
IMPACT OF CSMR ON SOLDER ALLOYS AND JOINT FAILURE

Caroline Nguyen, Kendall Stone, and Marc Edwards

Keywords: solder alloys, lead, tin, antimony, silver, copper

INTRODUCTION

Failures at soldered joints in copper tubes are relatively rare events. The conventional wisdom is that solder quickly develops protective coatings even in highly corrosive potable water. If a failure occurs at a soldered joint in a copper plumbing system, it is often attributed to poor workmanship.

Recently, in Greenville and Durham, NC, lead solders in copper potable water plumbing systems suddenly started corroding at a very high rate and triggered problems with lead release. For decades in these systems, the lead solder joining the joints of copper tubes had not caused significant lead in water problems, but pieces of the solder started falling off into the water and were trapped in aerators. The cause of the sudden attack on solder joints was traced to a change in water treatment by the utility. Specifically, at both utilities, the water coagulant was changed in a manner that shifted the chloride-to-sulfate mass ratio (CSMR) ratio of the water. Subsequent studies proved that a high CSMR could trigger very rapid galvanic attack at joints with lead solder. During the period of high lead leaching, one of the utilities maintained high pH and orthophosphate while another switched to high levels of orthophosphate without mitigating lead leaching. According to conventional criteria, the water would have been deemed relatively non-corrosive.

During galvanic corrosion, the copper pipe and the solder form a galvanic cell (a battery) in which the solder is sacrificed, and the copper pipe is protected. The high Cl^- and low SO_4^{-2} content of the water acts as a "switch" that reverses prior passivation of the solder that occurred when the water had a low $Cl:SO_4$ ratio. Other pre-conditions, such as low alkalinity and other factors, such as stagnation, might also be required for the severe galvanic attack between the copper pipe and lead solder to occur.

The potential adverse impacts of higher corrosivity at high CSMR are not just limited to lead contamination of the water. Some utilities have reported failures at copper and solder joints in systems where the coagulant has been changed, even when lead-free solder (< 0.25% Pb) is used. This is not unexpected, since galvanic corrosion that can cause pieces of solder to fall off into the water can also be expected to weaken joints. Even modern lead-free solders might not be immune to this problem because antimony and tin are also anodic to copper, and might be subject to galvanic corrosion under certain water quality conditions.

Due to the high cost of water damage from failed plumbing in homes and buildings, this chapter focused on examining the interplay between CSMR, solder alloy composition, and rate of attack on solder joints. In addition to the obvious value of this work to the water industry/EPA/plumbing industry in terms of understanding the longevity of premise plumbing systems, the research also improves the understanding of corrosion mechanisms as a function of solder alloy composition. Leaching of other metals of potential health concern, such as antimony, silver, and tin, were also explicitly examined in these experiments.

MATERIALS AND METHODS

Apparatus for Copper-Solder Joint Study

Six solder alloys were evaluated for Parts 1 and 2 of this study (Table 2.1). For Part 1, pure lead and tin wires were also evaluated.

Part 1

The first part of the work attempted to examine mechanistically the impacts of CSMR on solder corrosion. Simulated joints with solder wire pieces connected to copper pipes were exposed to low and high CSMR water (Figure 2.1). Each piece of wire had an exposed surface area of approximately 6.2 cm^2 inside the copper pipe. The solder wires were between 0.5 mm and 3 mm in diameter (Table 2.1) and were positioned in the apparatus to remain inside the ½" copper pipe (Figure 2.1).

The apparatus consisted of a ¾" diameter copper pipe and a ½" diameter copper pipe that were connected by clear tubing with an approximate 2-mm gap between the two copper pipes (Figures 2.1 and 2.2). The smaller diameter (½") copper pipe was used to isolate water located near the surface of the anodic solder. The larger diameter (¾") pipe had the dual purpose of allowing electrode measurements inside the pipe, and providing a large copper-to-solder surface area of approximately 31:1. To simulate the galvanic connection between copper pipes and solder at joints while having the ability to measure corrosion activity with an ammeter, the solder and the copper pipes were electrically connected with copper wires.

Table 2.1
Description of solder wires used in the study

Wire	Weight Composition	Diameter (mm)
Lead/tin solder	50% (Pb), 50% (Sn)	3
Tin/copper solder	97% (Sn), 3% (Cu)	3
Tin/antimony solder	95% (Sn), 5% (Sb)	3
Tin/copper/silver solder	95.5% (Sn), 4% (Cu), 0.5% (Ag)	3
Tin/copper/selenium solder	Unknown	3
Nickel/silver/copper/tin/antimony solder	Unknown	3
Tin wire	99.9% (Sn)	0.5
Lead wire	99.9% (Pb)	1

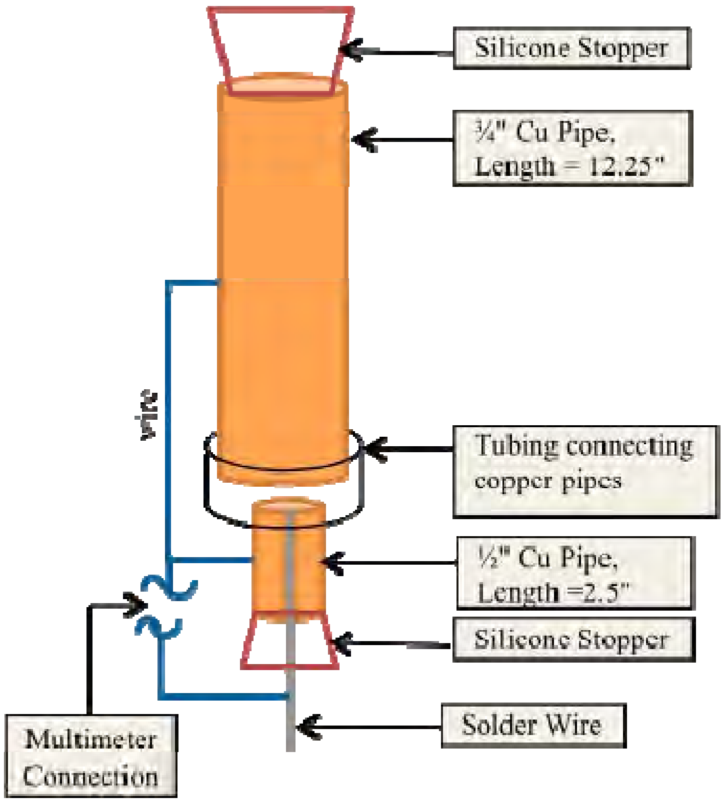


Figure 2.1 Schematic of copper-solder couple

Figure 2.2 Lower portion of the Part 1 apparatus. The solder is suspended in the center of the lower portion by the silicone stopper.

Part 2

The second part of the work applied the knowledge gained in the first part to test simulated solder-copper joint failure. The joints were designed to allow corrosive attack to proceed in a narrow crevice, and to confirm whether the highly corrosive conditions could actually cause a joint failure. The apparatus (Figure 2.3 and 2.4) consisted of a large sheet of copper (7.75” wide x 7” tall x 0.062” thick), to which three squares of copper sheet were soldered. In each case, a small amount of solder was carefully weighed (0.011 g ±0.002) and used to attach small squares of copper (each 1” x 1” and 9.3 g ±0.4) to the larger sheet. The copper sheets and squares were 0.062-in thick, 14 gauge and consisted of alloy C11000 manufactured to ASTM-B152.

The aforementioned apparatus simulates: 1) the large amount of copper exposed to the water in a copper plumbing system, 2) a soldered connection between two pieces of copper, and 3) a natural crevice between the two pieces of copper, under which the solder structurally holds together the joints. New simulated solder-copper joints were also prepared at the end of Part 2 to compare the strength with the simulated joints exposed to water for 1 year.

Test Water and Measurements

Part 1

This part of the study lasted a total of 11 weeks. The simulated joints were tested in triplicate and were exposed to synthetic water with low and high CSMR, which were 0.2 and 16, respectively (Table 2.2). A CSMR of 16 was chosen to represent the worst-case scenario in terms of water corrosivity. CSMRs in excess of 16 have been measured for various communities,

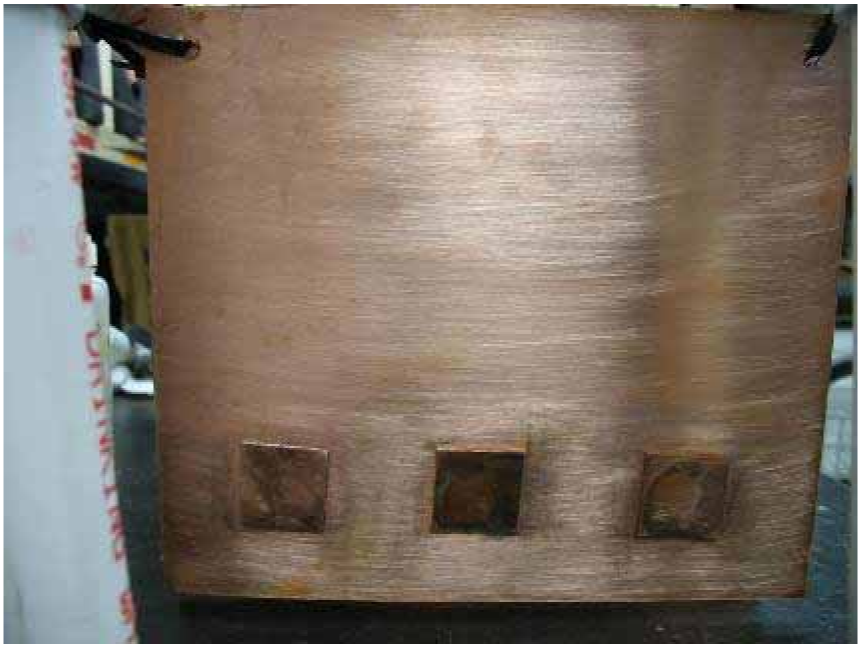


Figure 2.3 Experimental setup for Part 2 where various solder alloys were exposed to water.

Figure 2.4 Six sheets with different solder alloys. Two end copper sheets are the control sheets with no solder.

and the project team wanted to select an extremely aggressive condition because the goal was to examine if some types of solders are more impacted by these problems than others. All waters were dosed with chloramines at a concentration of 4 mg/L as Cl_2 with a ratio of 4:1 mg Cl_2/mg N, and the pH of the water was adjusted to pH 8.3 ±0.1 at each water change. The water was changed three times per week using a "dump and fill" protocol.

The water from each condition throughout the week was collected and analyzed for lead, tin, copper, and other metals using ICP-MS in accordance with Standard Method 3125. Additionally, sampling of individual replicates for each condition was conducted during Week 10 to obtain confidence intervals.

In addition to metals analysis, pH and chloride measurements were conducted twice during the study for the water near the solder and copper surfaces using an MI-406 flat membrane pH microelectrode (Microelectrodes, Inc) and a Lazar electrode, respectively. The measurements were taken by slowly lowering the microelectrode from the top of the copper joint, making pH or chloride measurements at 1" and 3" from the top of the pipe. After measuring at the cathode (i.e., top of the joint), the large copper pipe piece was disassembled at the plastic tubing, which connected the large copper section with the small copper. The pH was then measured in the disassembled joint at the solder surface within the smaller copper pipe section. The pH microelectrode was calibrated before each set of measurements, and the localized pH was measured for each replicate. Trends in pH were consistent throughout the study. While it is unavoidable to slightly mix the water during such measurements, any mixing would tend to make the measured differences in concentration less significant versus the conditions found in stagnant pipes.

Galvanic measurements including current, potential drop, and corrosion potential were performed monthly. The measurements were conducted 1 hour after a water change.

Part 2

The second part of the work was conducted for 12 months. Based on results from Part 1, the copper sheets with the simulated solder joints were exposed to 25 L of high CSMR water in a single reservoir (Table 2.2). A high CSMR water that had been determined to be much more aggressive to simulated soldered joints compared to low CSMR water was used for testing. Water was changed in the reservoir every other week. The pH was adjusted at least 5 times per week, and the chloramines concentration was maintained at 4 mg/L Cl_2 twice per week. At the end of the study, stress testing was conducted on the simulated copper joint sheets to determine the maximum load for each replicate joint. An MTS 4204 instrument with TestWorks 4.0 software was used to conduct the load test (Figures 2.5 and 2.6).

RESULTS AND DISCUSSION

In the first part of the work metals concentrations, pH, and galvanic currents were measured for solder-copper couples exposed to low and high CSMR water. In the second part of the work, simulated copper joints were exposed to high CSMR water, which was determined to be more corrosive than low CSMR water in Part 1, and subjected to stress testing at the end of 1-year exposure. There was no significant selenium released from solder; therefore, only tin, lead and antimony results are described in this report.

Review of Previous Studies and Synthesis of Data from Earlier Lead Work (Part 0)

Prior to the start of this study, a review of results from previous work related to tin solders was performed. This includes data collected by Nguyen (2005) and in other case studies conducted for this work. Hypothetically, because tin is found in most solder (Table 2.1), accelerated corrosion of tin may decrease the longevity of soldered joints. One important factor in tin solder corrosion appears to be the presence of orthophosphate. In one study, dosing of

Table 2.2
Water Quality for Joint Failure Study

Parameter	Concentration	
	Low CSMR	*High CSMR*
pH	8.3	8.3
Chloramines (mg/L Cl_2)	4	4
Chloride (mg/L Cl)	22	129
Sulfate (mg/L SO_4)	121	8
CSMR (mg/mg)	0.2	16
Alkalinity (mg/L as $CaCO_3$)	10	10
Magnesium (mg/L Mg)	2	2
Potassium (mg/L K)	3.7	3.7
Sodium (mg/L Na)	23.4	23.4
Calcium (mg/L Ca)	55.9	55.9
Nitrate (mg/L N)	1.3	1.3

Figure 2.5 Peak loading instrument to test simulated soldered joints at end of study.

Figure 2.6 Picture of 95/5 Sn/Sb simulated joint during stress testing at the end of the study (middle of photo). At left in the picture of a simulated joint after failure during the stress test.

1 mg/L PO_4-P increased the amount of tin released by as much as 10 times from 50:50 Pb/Sn solder connected to copper compared to the same condition without phosphate (Figure 2.7). This was observed for 1-ft long copper pipes dipped into 1-in of molten 50:50 Pb/Sn solder and exposed to simulated Potomac River water at two pH levels (7 and 9.5) and two levels of chloramination (0 and 5 mg/L Cl_2). The type of disinfectant (free chlorine and chloramines) appeared to have no effect on tin corrosion in the study for Utility I (Figure 2.8).

Another factor that affects the corrosion of tin in addition to other metals is the CSMR of the water, which was observed in three case studies. In the case of Greenville Utilities Commission in North Carolina (NC), using polyaluminum chloride (PACl) coagulant or a coagulant blend with PACl increased tin release from 50:50 Pb/Sn solder compared to when aluminum sulfate (alum) coagulant was used (Figure 2.9). In another case study in NC (Utilities B and E), ferric sulfate, ferric chloride, blends of ferric sulfate and ferric chloride, and anion exchange treatment were evaluated as strategies to treat water. Consistent with previous findings, increasing CSMR of the water resulted in increases in the tin release from galvanic connections of 50:50 Pb/Sn solder and copper (Figure 2.10).

The effect of CSMR on tin leaching was also seen with desalinated salt water, which had as much as 100 mg/L Cl and less than 5 mg/L SO_4 (i.e., high CSMR). Increasing the percentage of desalinated or nanofiltered water blended with groundwater for Utility K in California increased the tin released from 50:50 Pb/Sn solder that was connected to copper (Figure 2.11).

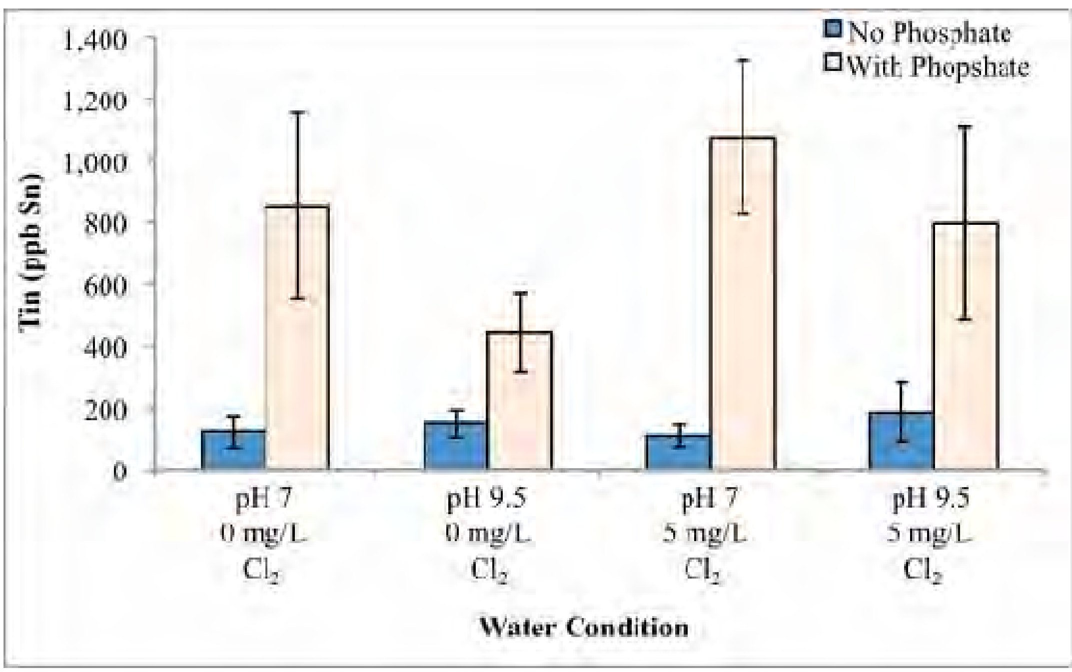


Figure 2.7 Tin release in water with and without orthophosphate. The water contained 0 or 5 mg/L chloramines as Cl_2 and had a pH of 7 or 9.5.

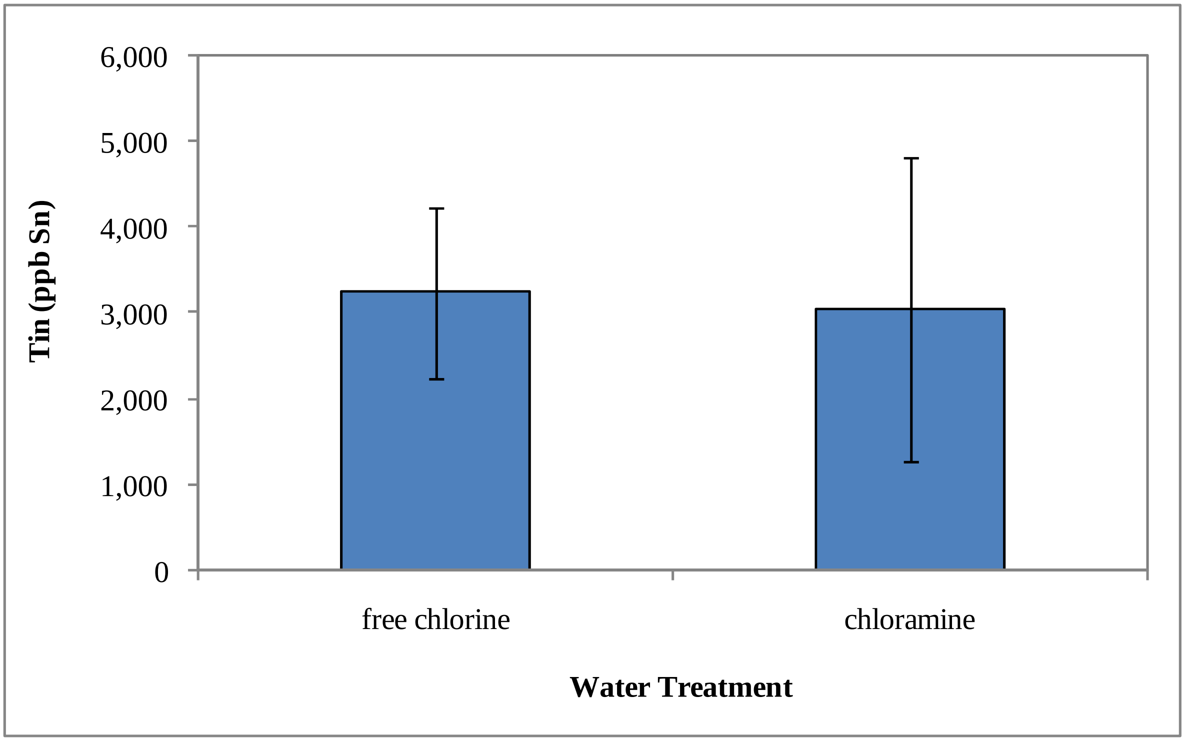


Figure 2.8 Tin release from a Maryland utility water treated with alum or PACl coagulants and disinfected with either free chlorine or chloramines. There was no evidence that the water conditions treated with free chlorine were any different from water disinfected with chloramines in terms of tin leaching.

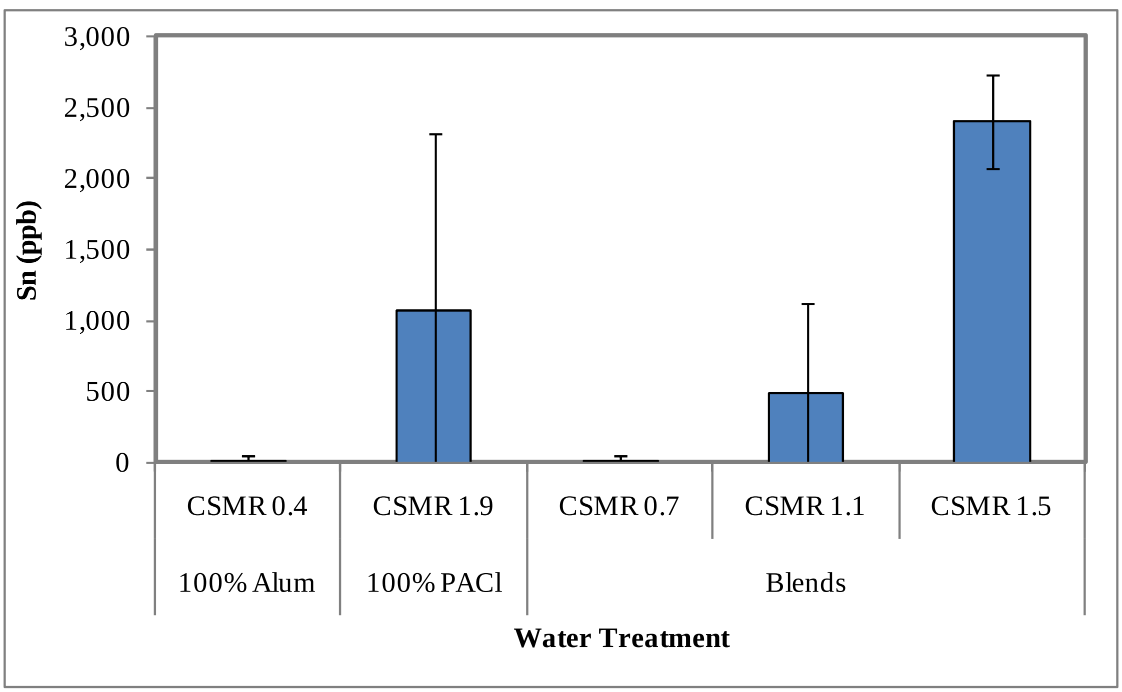


Figure 2.9 Effect of CSMR on tin release from 50:50 Pb/Sn solder galvanically connected to copper for water from a utility in NC.

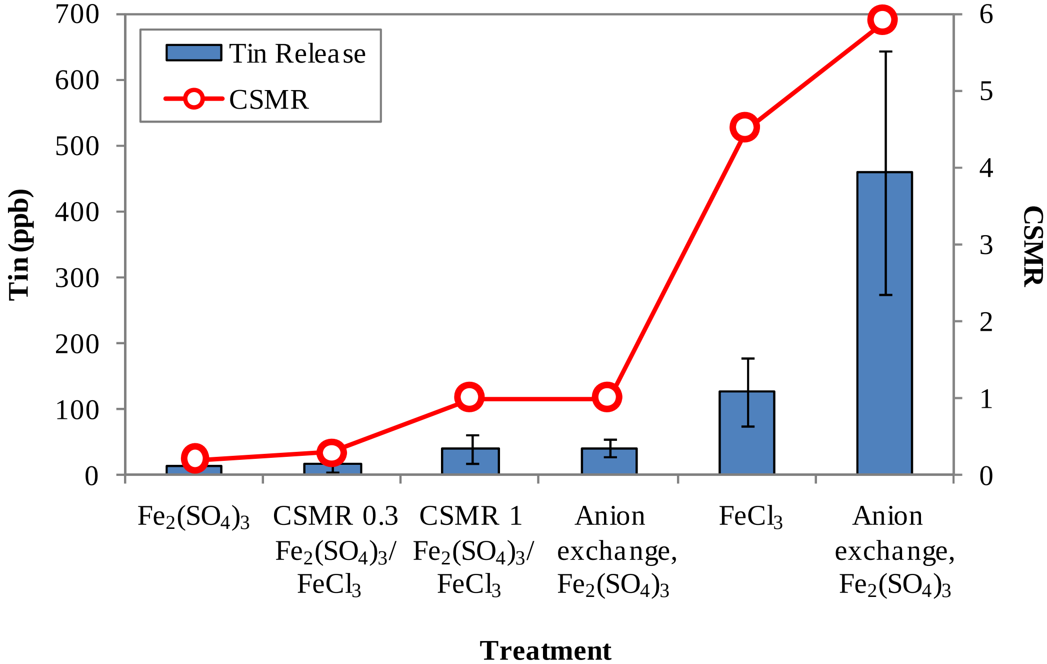


Figure 2.10 Tin release from water treated with sulfate-based coagulants, chloride-based coagulants, and anion exchange.

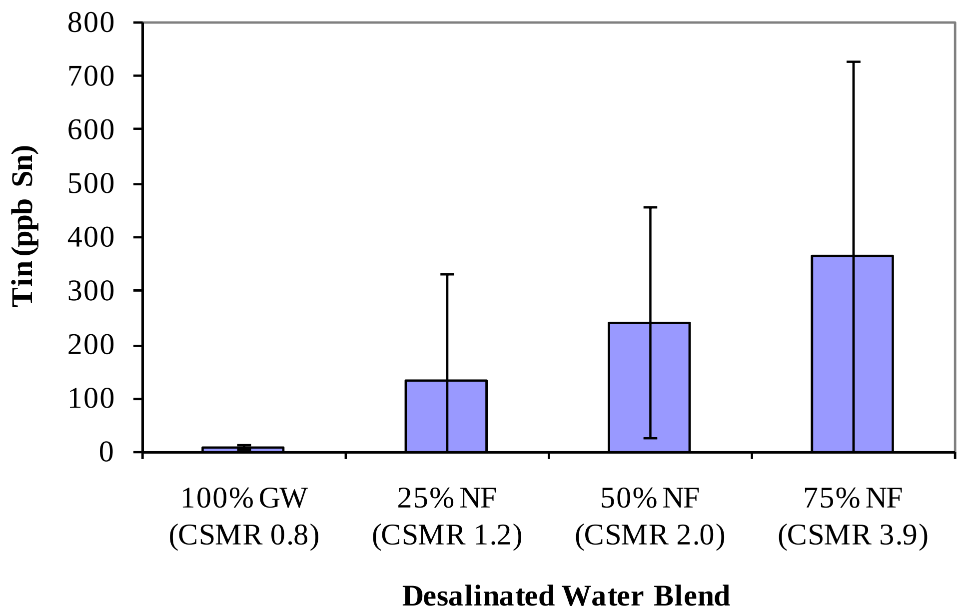


Figure 2.11 Effect of desalinated (nanofiltered or NF) water blends on tin release. Increasing blends of desalinated water, which has high CSMR, results in higher levels of tin released to the water.

Effect of Low and High CSMR Water (Part 1)

Tin Release

Samples collected during Week 10 illustrated that tin leaching was higher in water with high CSMR. For instance, the solder alloy with 97/3 tin/antimony had almost 7 times more tin released in high CSMR water than in low CSMR water (Figure 2.12). Overall, tin release increased between 3 and 11 times in high CSMR water compared to low CSMR water for the tin solder alloys tested. Clearly, the adverse galvanic effects of a high CSMR water are not limited to the lead:tin solder alloys.

During Week 10, tin release from pure tin wire appeared to be unaffected by the CSMR. However, the tin release from tin wire had been an average of 28 times worse in high CSMR water than low CSMR water during the first 10 weeks of the study (Figures 2.13 and 2.14). Additionally, tin leaching from all of the solder alloys and tin wire exposed to high CSMR water was more variable than in low CSMR water throughout the 11-week study (Figure 2.14).

Lead Release

High CSMR water significantly increased lead leaching at the 99% confidence level for pure lead wire and 50/50 Pb/Sn wire connected to copper pipes. For instance, the lead release from 50/50 Pb/Sn solder increased 35 times when the solder-copper couples were exposed to high CSMR water (Figure 2.15). Similarly, lead release from pure lead wire increased 18 times due to high CSMR. The results are consistent with theory since higher CSMR accelerates galvanic reactions that occur between lead and copper (Figure 2.16).

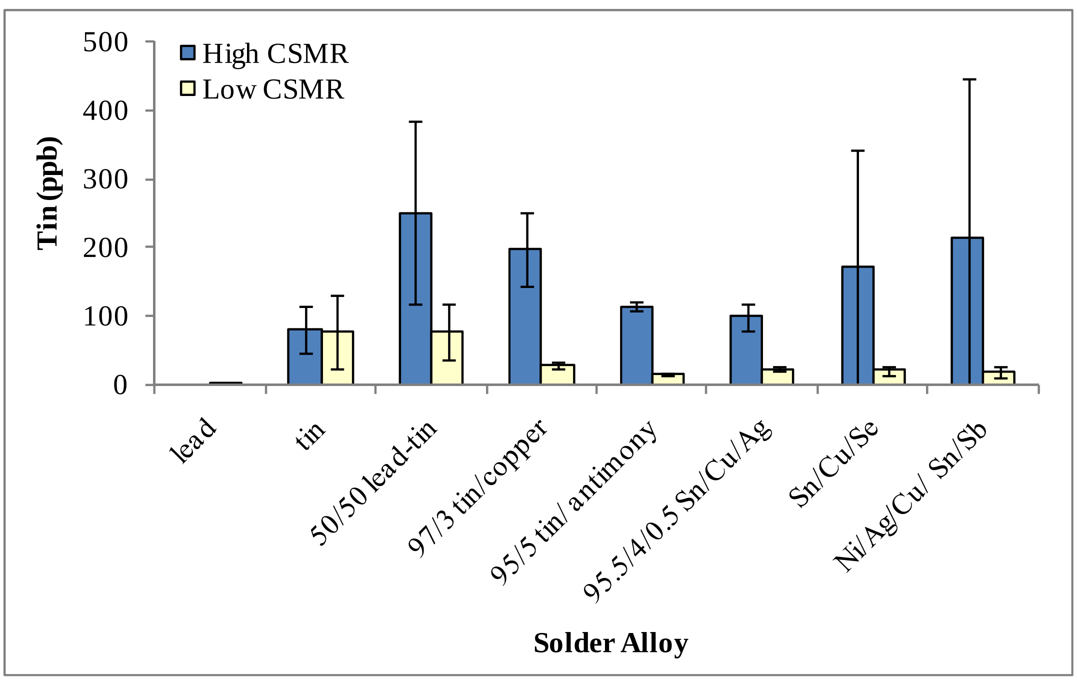


Figure 2.12 Tin release from high and low CSMR waters from each of the alloys during Week 10 in Part 1 of the study. The error bars represent the 95% confidence intervals among the 3 replicates at each condition.

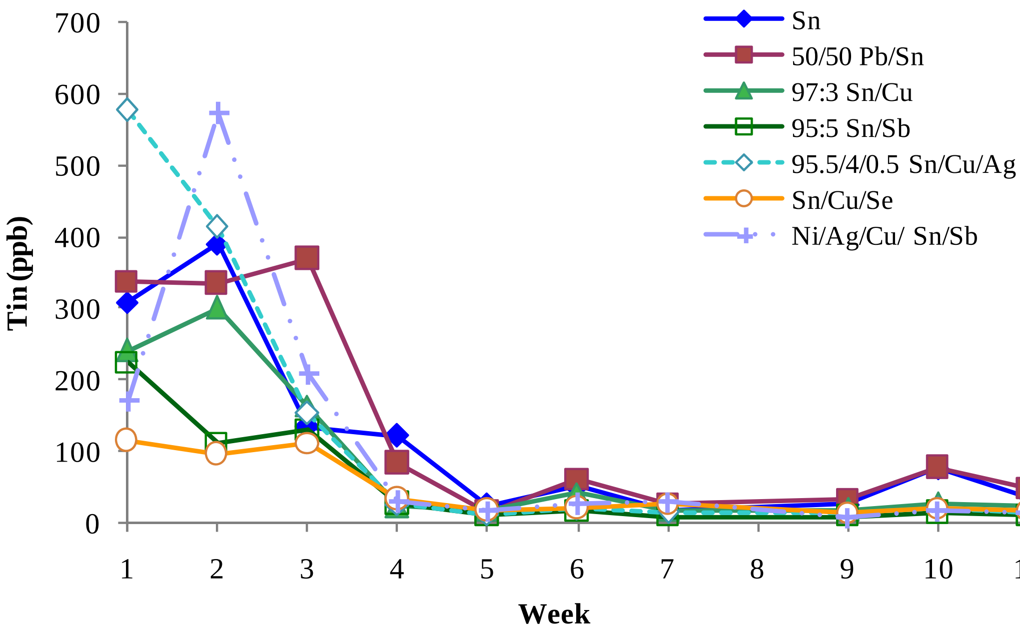


Figure 2.13 Tin release as a function of time for low CSMR water of 0.2 in Part 1 of this study.

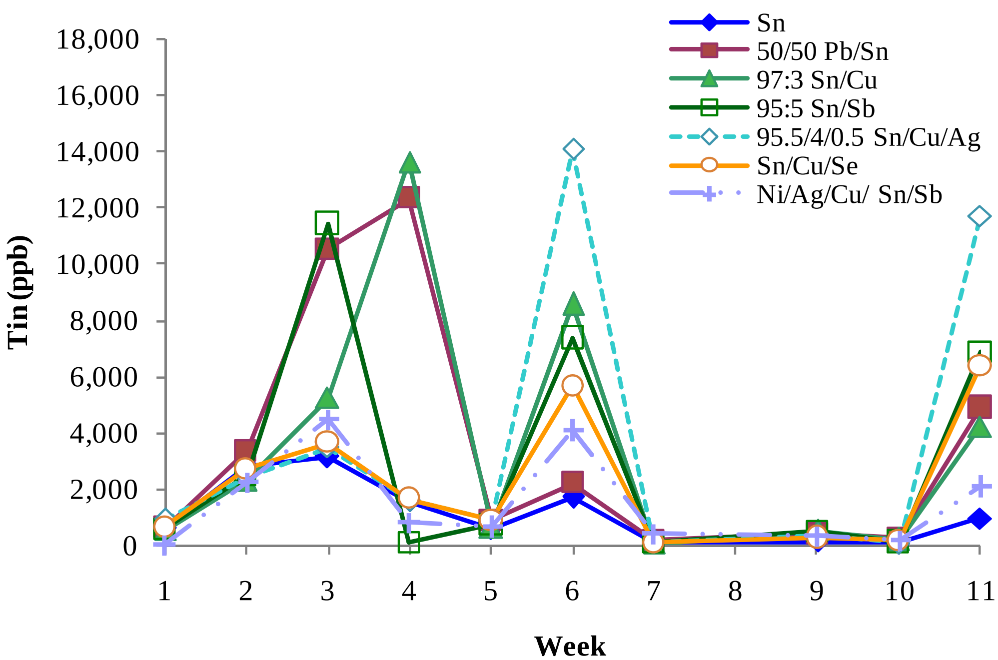


Figure 2.14 Tin release as a function of time for high CSMR water of 16 in Part 1 of this study.

Comparing the lead materials, 50/50 Pb/Sn solder had similar levels of lead compared to pure lead wire in both low and high CSMR waters. In high CSMR water, the pure lead wire and the 50/50 Pb/Sn solder were not significantly different in terms of lead leaching (Figure 2.15). However, in low CSMR water, the lead leaching was about 1.5 times greater for pure lead wire than for 50/50 Pb/Sn solder and was statistically significant at the 99% confidence level during Weeks 5-9 but not at Week 10 alone. This suggests that higher CSMR could increase lead leaching for these two lead materials galvanically connected to copper.

Antimony Release

Antimony is a concern because it is considered a carcinogen after long-term exposure and causes health effects such as nausea and vomiting with short-term exposure. To protect the population, the US EPA has set the maximum contaminant level (MCL) for antimony to be 6 ppb. Due to this concern, a goal of this study was to determine the amount of antimony that may be released from plumbing materials, or in this study the 95/5 tin-antimony and Ni/Ag/Cu/Sn/Sb solders. Herrera et al. (1982) found that for tin/antimony solders, tin would become the sacrificial anode and protect antimony.

In contrast to the release of the lead and tin metals from solder, antimony release was worse for low CSMR water. Antimony is recognized as a metalloid that does not act chemically like a metal. In this study, antimony release from 95/5 Sn/Sb solder increased from undetectable levels in high CSMR water to 2.8 μg/L in low CSMR water (Figure 2.17). Similarly, solder containing Ni/Ag/Cu/Sn/Sb exposed to low CSMR water had an increase in antimony release from 0.1 μg/L to 1.3 μg/L, or a factor of 13 times. However, for this study, the antimony levels remained below the MCL of 6 ppb.

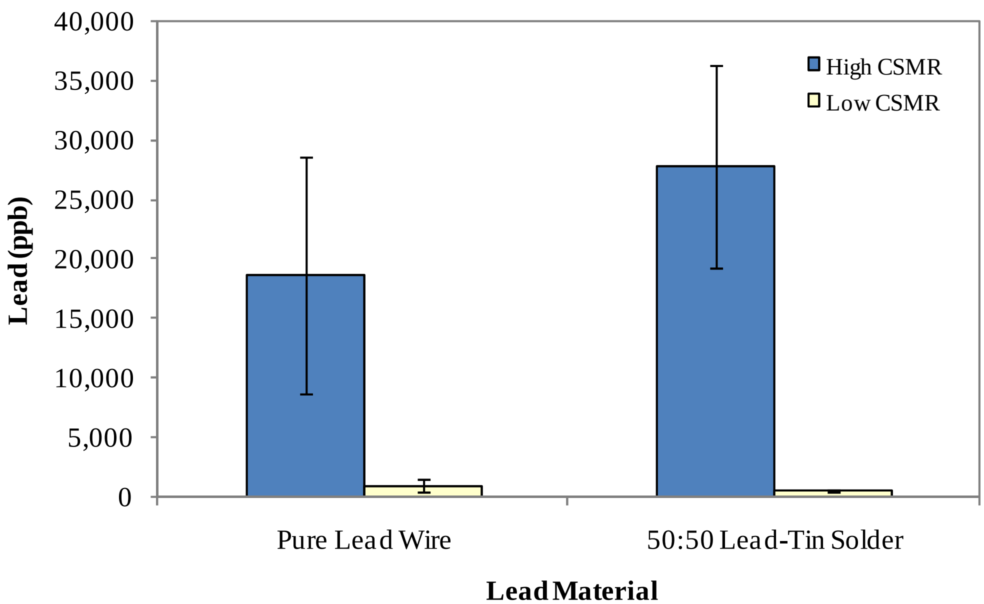


Figure 2.15 Lead leaching from pure lead wire and 50:50 lead-tin solder in low (0.2) and high (16) CSMR water during Week 10 in Part 1. The error bars indicate the 95% confidence intervals.

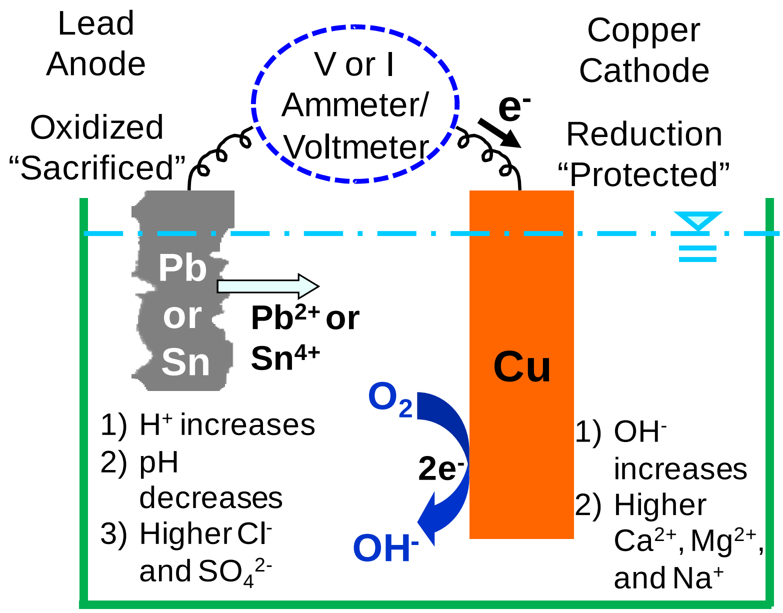


Figure 2.16 Reactions at lead or tin anode and copper cathode surfaces

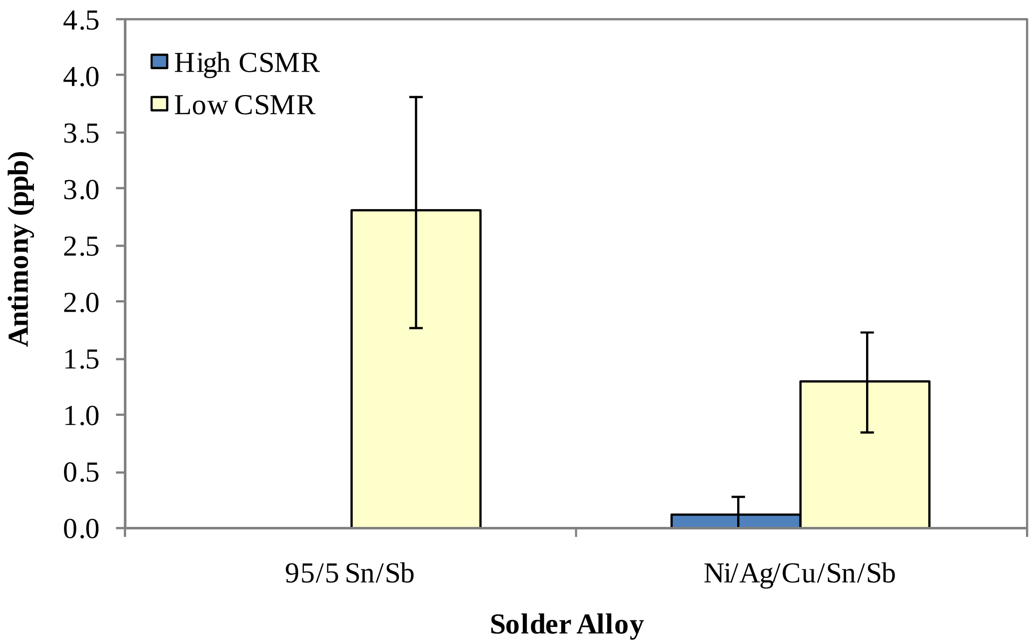


Figure 2.17 Release of antimony from 95/5 Sn/Sb solder and solder containing Ni, Ag, Cu, Sn, and Sb during Week 10 in Part 1 of the study. The CSMRs of the high and low CSMR waters were 16 and 0.2, respectively.

Galvanic Currents

The galvanic current measurements indicated that high CSMR water generally produced higher currents, or higher corrosion rates of the solders and wires, compared to low CSMR water (Figure 2.18). The currents reflected similar trends as the tin and lead leaching data in terms of the impact of CSMR. Any differences in currents and tin leaching may be explained by the release of other metals, such as lead, from the solders or wires.

The theoretical amount of metals release was also calculated based on the galvanic current. Because tin is a major component in all of the solders evaluated in this study, the theoretical and actual tin dissolution values were compared. The typical oxidation state of tin is +4. Therefore, as tin corrodes, 4 electrons (e^-) are released for each mole of tin leached (Sn^{4+}): $Sn_0 \rightarrow Sn^{4+} + 4e^-$. The maximum leaching of tin from the tin solders can be calculated from the following equation, assuming that the current measured at a given time remains constant, an average stagnation period of 2.33 days, and correcting for percent tin in the solder:

$$Maximum\ Sn\ Leaching\ (g) = \frac{I\left(\frac{Coulomb}{\text{sec}}\right)\times T\ (\text{sec})\times 118.7\left(\frac{g\ Sn}{mol\ Sn}\right)}{1.6\times10^{-19}\left(\frac{Coulomb}{e^-}\right)\times 6.023\times10^{23}\left(\frac{Sn}{mol\ Sn}\right)\times 4\left(\frac{e^-}{Sn}\right)}$$

The calculated and actual tin release were correlated. However, actual tin leaching from solder was approximately 40 times lower than would be predicted based on the above galvanic current measurement (Figure 2.19). The discrepancy could be explained by a number of factors. For example, the galvanic current used for the calculation provides a snapshot in time of the

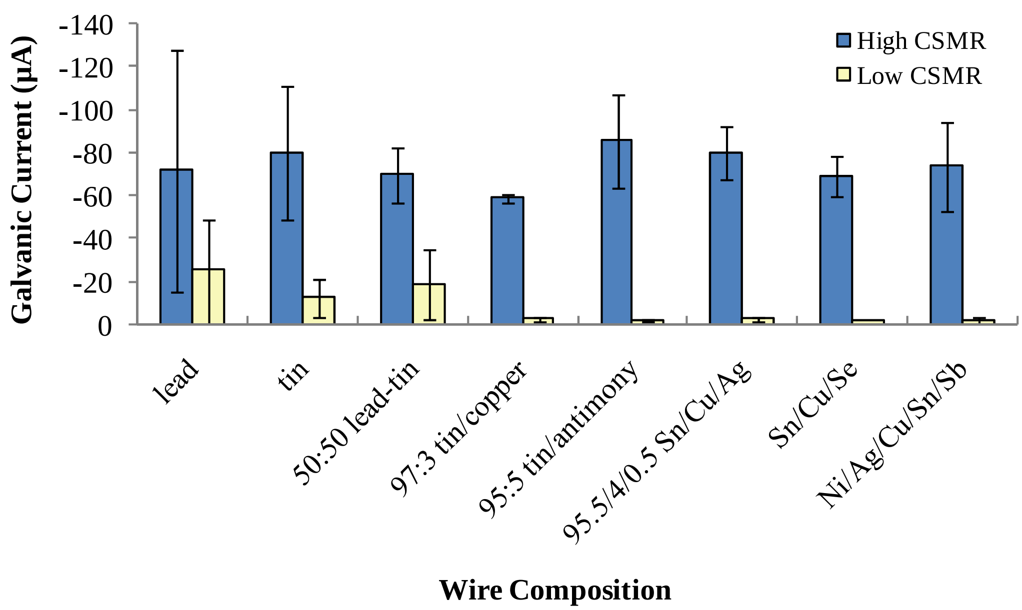


Figure 2.18 Galvanic currents measured in the simulated joint apparatus during Week 5 one hour after a water change for the low and high CSMR water conditions in Part 1. The CSMRs of the low and high CSMR waters were 0.2 and 16, respectively.

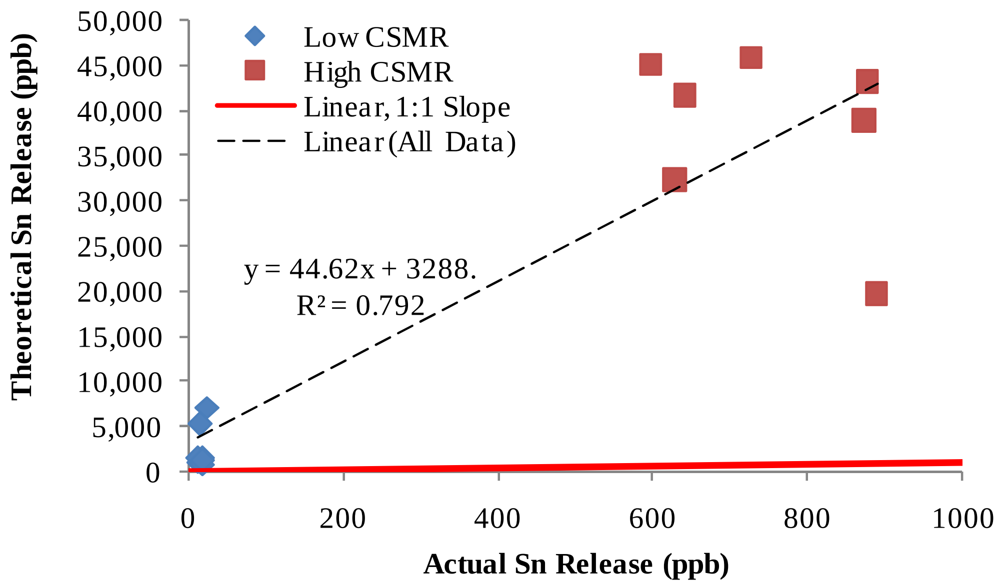


Figure 2.19 Comparison of theoretical versus actual tin release for the first part of the study. The theoretical tin release was calculated from the galvanic currents and was approximately 40X higher than the actual measured concentrations. The red line represents the hypothetical 1:1 relationship between the calculated and actual tin release.

corrosion rate while the tin leaching data is an average of the metal release during a given stagnation period. During stagnation, the galvanic current might tend to decrease somewhat as oxidants in the water are depleted. Regardless, there is a roughly linear correlation between the observed tin leaching and the calculated values.

pH at Surface of Solder and Copper

The pH of water near the surface of the copper cathode (i.e., upper portion of the copper pipe apparatus) and near the solder anode were measured. Generally, the pH decreased at the solder surface compared to the surface of the copper cathode (at least 7” away from the solder) consistent with theory. High CSMR exacerbated the pH difference between the solder or wire and the upper regions of the copper.

Low CSMR water. In low CSMR water, the pH was as low as 6.6 at the surface of the 50/50 Pb/Sn solder, which represented a pH drop 1.1 pH units compared to the pH at the copper cathode surface (Figure 2.20). The next largest pH drop was measured for the Ni/Ag/Cu/Sn/Sb solder, which had a pH drop of 0.5. The other solder alloys and wires had below 0.5 pH unit drops. The pH at the copper surface was an average of pH 7.3. Generally, the pH was not as acidic in low CSMR water compared to high CSMR water, which is expected given the trend in galvanic current.

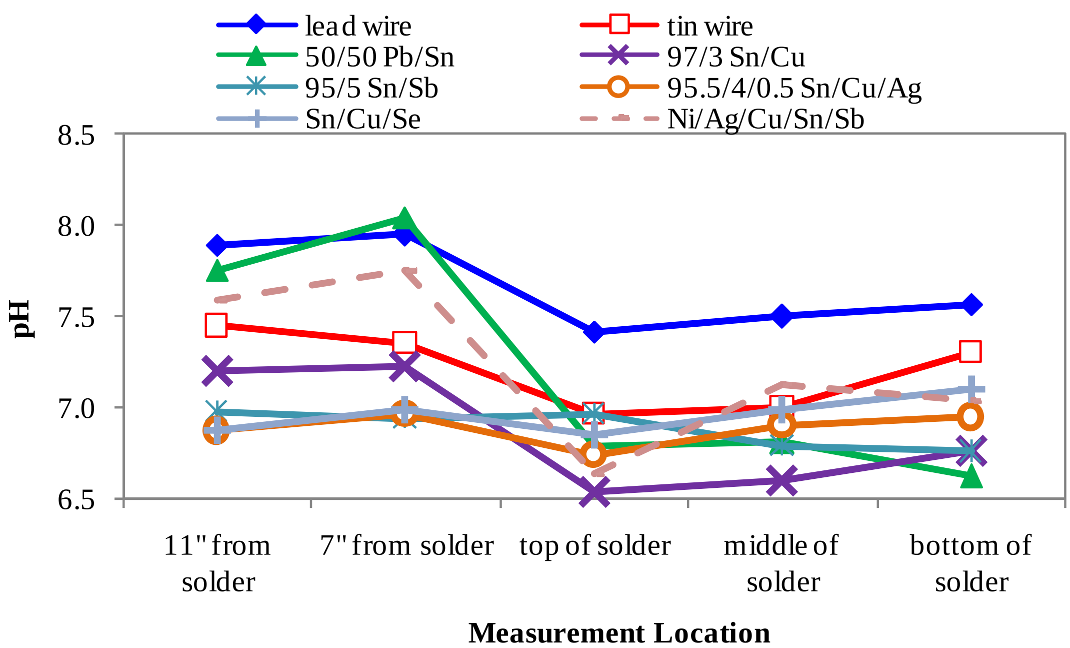


Figure 2.20 pH measurements near the surface of the copper and solder for simulated joints exposed to low CSMR water in Part 1. The CSMR was 0.2.

High CSMR water. For high CSMR water, the pH at the solder or wire surface was as little as 0.7 pH units and as high as 7 pH units lower than water at the top of the apparatus (Figure 2.21). The pH was as low as 3.0 at the surface of the 50/50 Pb/Sn solder and the 97/3 Sn/Cu solder. At the copper cathode surface, the pH was approximately pH 9.4 for all the solder alloys and wires, or 2 pH units greater than measured in the low CSMR water. The acceleration of galvanic reactions occurring at the surfaces of the solder and the copper pipe due to high CSMR (Figure 2.16) caused the pH to be lower at the solder anode and higher at the copper cathode.

Local Chloride Measurements

More chloride tended to accumulate at the solder alloy surfaces when exposed to high CSMR water than low CSMR water. For low CSMR water, the chloride concentration along the surface of the apparatus was the same, with the exception of the 97/3 Sn/Cu solder (Figure 2.22). In that case, the chloride concentration doubled from 22 mg/L Cl in the initial bulk water to 40 mg/L Cl at the solder surface.

For high CSMR water, which accelerates galvanic corrosion and reactions in Figure 2.15, the chloride concentration was depleted at the copper cathode surface (located 11” from the solder). The initial bulk water concentration was approximately 129 mg/L Cl but decreased to between 42 and 82 mg/L Cl at the cathode (Figure 2.23). The chloride increased to as high as 215 mg/L at the bottom of the solder surface. The three solder alloys with the highest chloride were 50/50 Pb/Sn, 95/5 Sn/Sb, and 97/3 Sn/Cu solders. In contrast, the pure lead and tin wires did not appear to have salt accumulation at the surface of the wires.

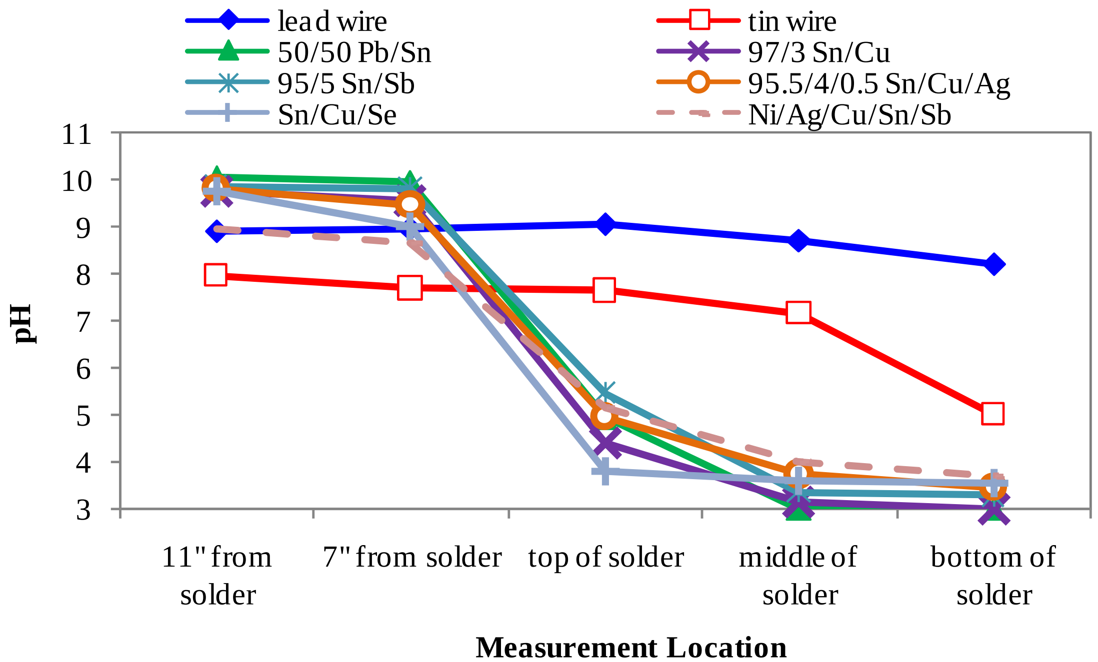


Figure 2.21 pH measurements near the surface of the copper and solder for simulated joints exposed to high CSMR water in Part 1. The water had a CSMR of 16.

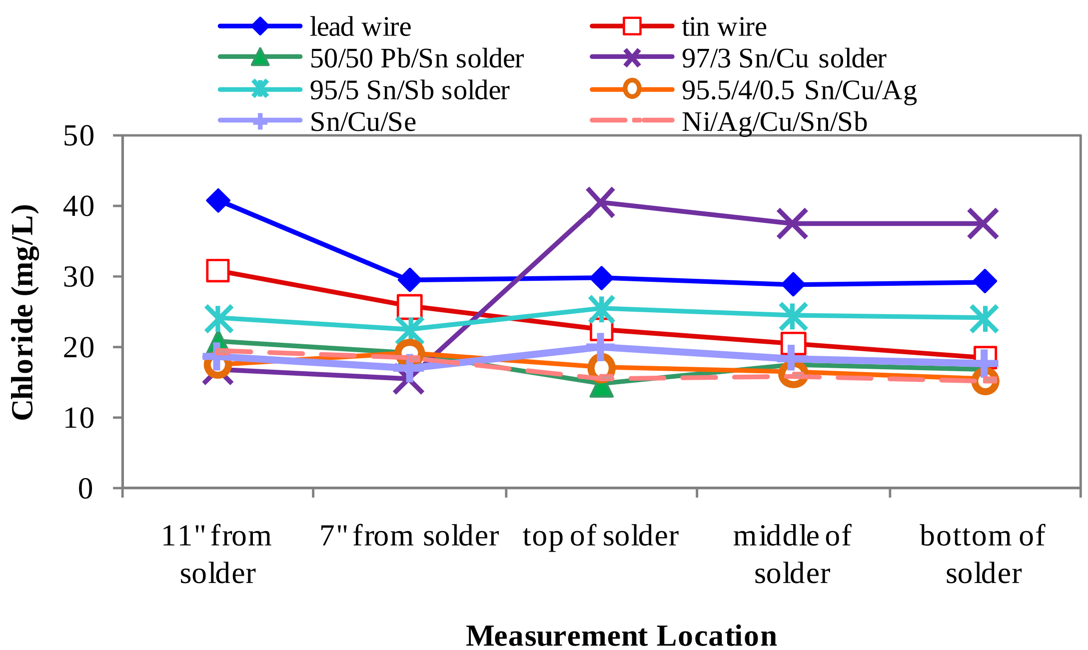


Figure 2.22 Microelectrode chloride measurements at the surface of the copper and solder for the simulated joints exposed to low CSMR (0.2) water in Part 1.

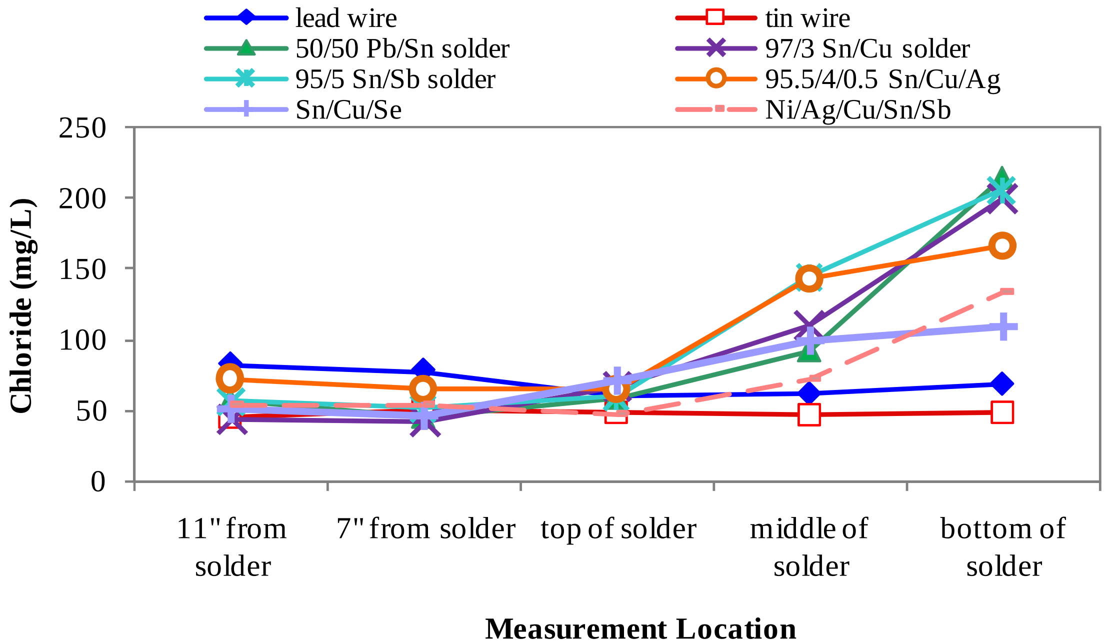


Figure 2.23 Microelectrode chloride measurements at the surface of the copper and solder for simulated joints exposed to high CSMR (16) water in Part 1.

Load Testing (Part 2)

Based on results from Part 1, the high CSMR water was more corrosive for metals such as tin and lead, and corresponding with measurement of lower pH and higher chloride at the solder surface. Therefore, in Part 2 of the study, simulated soldered joints were prepared for tin wire and the six solder alloys and exposed to high CSMR water for 12 months (Figure 2.4). At the end of the 12-month exposure to high CSMR water, the strength of the simulated joints was tested by determining the maximum load that each joint could sustain before failing. The loads were compared to that which were present in new simulated soldered joints. In some cases the joint "failed" during testing without applying any load at all, as the soldered copper detached from the large copper sheet naturally. In these cases the load was recorded as "0" strength.

In each and every case, there was a significant reduction in the peak load for the simulated soldered joints after 1-year exposure to high CSMR water, and preliminary results indicate that significant amount of solder was lost via corrosion from the simulated joints. The loads decreased from 260-740 lbf before exposure to as low as 0-130 lbf after being exposed to high CSMR water for 12 months (Figure 2.24). The most significant reduction in load was observed for 97/3 Sn/Cu solder, where each joint replicate naturally failed or detached the end of the study (i.e., load reduction of 100%) (Figure 2.25). One replicate for the 97/3 Sn/Cu solder detached after approximately 10 months while the other two replicates for this condition detached as the apparatus was disassembled and prepared for load testing. Likewise, complete joint failure prior to load testing was also recorded for one replicate of the Sn/Cu/Se solder (after approximately 5 months) and one replicate of the nickel-bearing solder (after approximately 10 months).

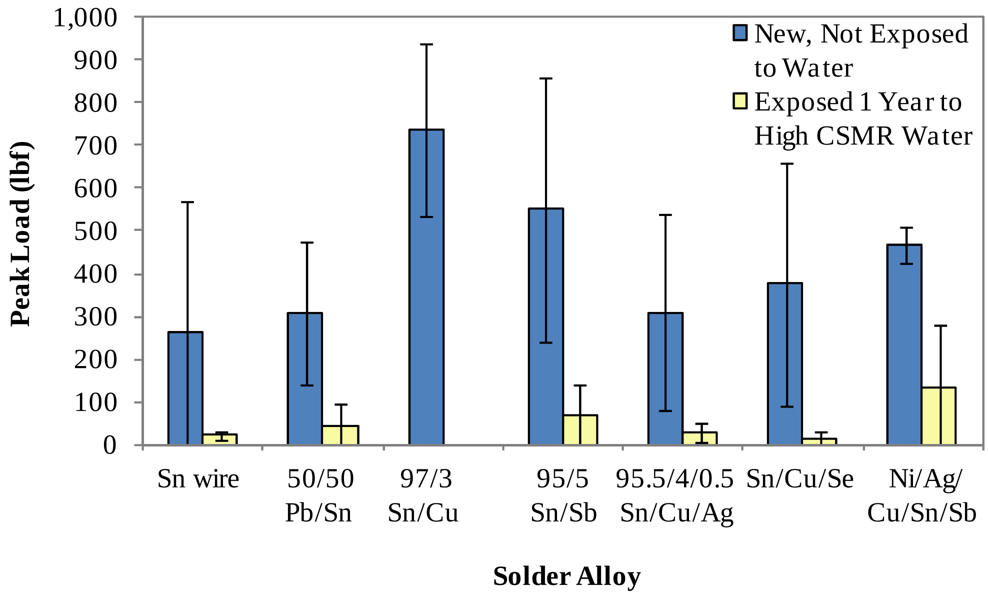


Figure 2.24 Average peak loads for new and exposed simulated copper-solder joints at the end of the second part of the study.

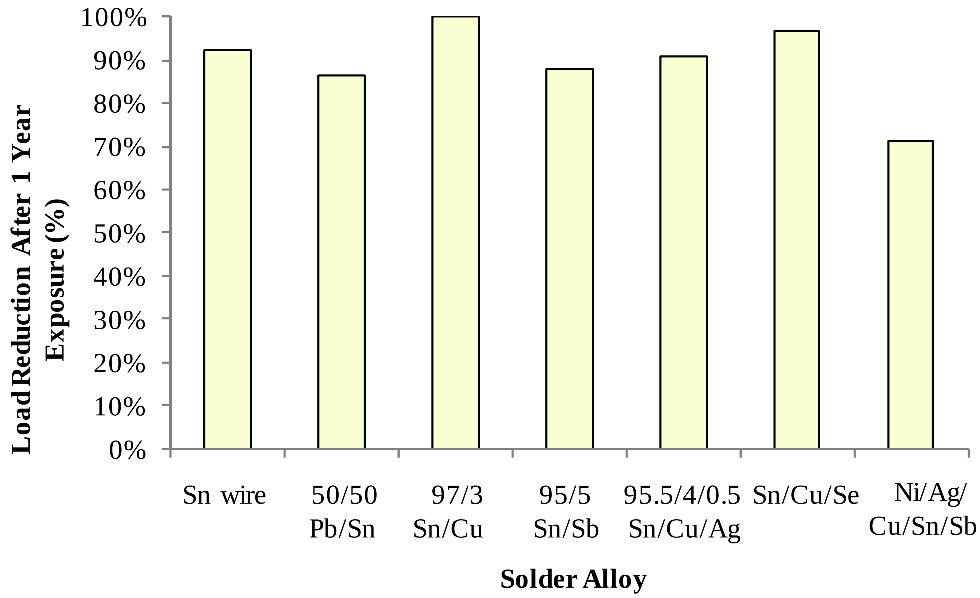


Figure 2.25 Percent reduction in load at the end of Part 2 of the study for each simulated soldered joint exposed to high CSMR water compared to new joints not exposed to water.

Based on the average peak load, the solder performance is ranked (from best to worst) in the following order:

1) Ni/Ag/Cu/Sn/Sb
2) 50/50 Pb/Sn
3) 95/5 Sn/Sb

4) 95.5/4/0.5 Sn/Cu/Ag (tied)
4) Sn wire (tied)
4) Sn/Cu/Se (tied)
7) 97/3 Sn/Cu

After exposure to high CSMR water, all of the soldered joints evaluated in this study had load reductions of 70-100%. Pure tin wire had a load reduction of 92%; however, these results were only significant at the 85% confidence interval. The peak load for the 50/50 Pb/Sn and the 95/5 Sn/Sb soldered joints were significantly reduced by 86% and 88%, respectively, as a result of exposure to high CSMR water, and the results were significant at the 95% confidence level (Figures 2.24 and 2.25). The Ni/Ag/Cu/Sn/Sb solder had the lowest load reduction of 71% ($p = 0.02$) compared to the other solder types. However, one replicate for the nickel-bearing solder failed after 10 months of exposure to high CSMR water.

CONCLUSIONS

- Generally, higher chloride-to-sulfate mass ratio (CSMR) and dosing of orthophosphate increased tin release from 50/50 Pb/Sn solder connected to copper pipe.
- High CSMR water increased corrosion rates of the solder alloys and pure metal wires connected to copper.
- Increased corrosion was also reflected in higher tin and lead concentrations in water exposed to the simulated joints.
- Contrary to results for tin and lead, the release of antimony from the two solder alloys containing antimony was worse in low CSMR water. However, in this study, the antimony release remained below the MCL of 6 ppb.
- The pH was measured to be as low as 3.0 at solder surfaces exposed to high CSMR water. Given the difficulties in measuring pH at the surface, these values should be considered an upper bound to the actual pH.
- The chloride concentration measured at the solder surface generally increased during stagnation compared to the level in the bulk water. No significant change in chloride concentration was measured for the pure tin and pure lead wires.
- The 97/3 Sn/Cu solder wire had the greatest reduction in joint strength after 1 year of exposure to high CSMR water.
- Based solely on peak load and excluding the nickel-bearing solder (Ni/Ag/Cu/Sn/Sb), which had a failure at month 10, the two solder types with the least structural damage were 50/50 Pb/Sn solder and 95/5 Sn/Sb solder. Of the two, 95/5 Sn/Sb had the lowest measured tin release.
- The 95/5 Sn/Sb solder had the most desirable characteristics of the solders evaluated in this study. The solder had the lowest load reduction after exposure to high CSMR water, did not release harmful levels of antimony (or lead, as would be the case for 50:50 Pb/Sn solder) to the water, and had less tin corrosion compared to the other solder types.

CHAPTER 3
OVERVIEW OF CASE STUDIES

In this project, nine case studies were conducted for 10 utilities across North America. These studies focused on the impacts of treatment changes on the lead leaching from common lead plumbing materials (lead solder and brass). These treatment changes included dosing of corrosion inhibitors, finished water pH, and treatment processes that affect the chloride and sulfate concentrations in the water. It has already been established that the coagulant (chloride-based versus sulfate-based) is a major factor in controlling lead leaching from solder-copper galvanic couples (Edwards and Triantafyllidou 2007) and was also evaluated in a range of waters in this project (Table 3.1), but other pathways discovered in this work include the uses of desalinated water, arsenic treatment, and anion exchange. Increases in chloride have also been associated with run-off of road salt during the winter into the water supply and a chloride leak into treated water from a hypochlorite generation system.

The impacts of these treatment changes on lead leaching were investigated in case studies described in Chapters 1 through 10 using static dump-and-fill methods to replace water in test coupons (Table 3.2). The case study presented in Chapter 11 used recirculating flow through pipe loops to test the impacts of chloride and sulfate in flow conditions typical in homes.

For the utilities where coagulant type was evaluated (Chapters 1 and 4-7), bench scale treatment of the utility raw water source (i.e., river water in these cases) was conducted to simulate treatment at the plant to the extent possible. Optimal coagulant doses were provided by the plant for each batch of water received at Virginia Tech. Coagulation mixing speeds and times (rapid mix for one minute, 20 rpm for 20 minutes, and settling for 30 minutes) were selected to simulate full-scale treatment in jar tests. Filtration was conducted using glass wool filters with the exception of the Canadian case study in Chapter 7.

"Optimization" of coagulation is a science and an art in its own right. Virtually all the utilities that participated in this project have noted substantial differences in coagulant performance in terms of TOC and turbidity removal in practice. For example, Greenville Utilities Commission in NC desperately wanted to use PACl due to marked improvements in turbidity removal after settling and filtration. Qualitatively, a deep sand filter does a better job of removing particles than the glass wool filter used at bench scale in the lab tests, but the relative performance advantages in this work for glass wool in terms of turbidity removal were the same as those noted by the utilities in practice. In each study, data were scrutinized to determine whether factors other than CSMR could explain the differences in lead leaching performance. In general, results agreed with those from very well controlled laboratory studies, in that changes in CSMR were the primary controlling factor in determining the extent of lead leaching from galvanic connections between copper and lead bearing plumbing materials.

Table 3.1
Summary of coagulants evaluated in EPA/Water Research Foundation Project 4088.

Utility	Chapter in Report	Coagulants Evaluated	CSMR	Summary of Findings and other Considerations
Greenville Utilities Commission, NC	5	Alum	0.4	After switching from alum to PACl, it took 1.5 weeks for the lead leaching to increase. Coupons exposed to low and high CSMR waters for 2 years showed no differences between the CSMRs. For this water, blending coagulants to achieve a CSMR of approximately 0.7 did not significantly increase lead leaching, and changes in alkalinity did not have a large effect on lead leaching compared to the effects of CSMR.
		Alum/PACl Blends	0.7	
			1.1	
			1.5	
		PACl	1.9	
B & E, NC	6	Ferric Sulfate	0.2	Water treated with ferric chloride consistently had more lead leaching from solder and brass than ferric sulfate (and the blend with CSMR 0.3). Anion exchange treatment with ferric chloride coagulation resulted in the highest lead levels, and phosphate corrosion inhibitors made lead leaching worse for that CSMR condition.
		Ferric Sulfate/ Ferric Chloride Blends	0.3	
			1	
		Ferric Chloride	4.5	
D, Nova Scotia, Canada	7	Alum	0.9	Lead release from lead:tin solder was not significantly different among the three water conditions tested. This might be because all waters were above the 0.5 CSMR threshold. At levels of CSMR above the 0.5 threshold, other factors such as alkalinity and organic carbon may control lead release.
		Ferric Sulfate	0.9	
		PACl	2.1	
G, NC	4	Alum	0.4	Chloride-based coagulants, which had CSMRs >1, had significantly higher lead levels than sulfate-based coagulants (CSMR of 0.4)
		Ferric Sulfate	0.4	
		Ferric Sulfate Polymer Blend	0.4	
		Ferric Sulfate/ Aluminum Chlorohydrate Blend	1.8	
		Ferric Chloride	3.1	
I, MD	1	Alum	1.4	Both CSMR levels that were evaluated resulted in high lead release from brass and solder. Because of the high CSMR of the waters evaluated, no significant differences were seen between PACl and alum in terms of lead leaching. However, PACl water dosed with simulated road salts (CSMR 8.4) resulted in about two times more lead than PACl or alum waters (with no road salts).
		PACl	5.3	

Table 3.2
Variables investigated in each bench scale test.

Utility Case Study	Chapter in Report	Alkalinity	Anion Exchange	NH_2Cl vs. Cl_2	Cl- Leak from Chlorine Generation	Coagulant Type	Desalination Blends	pH	Phosphate Inhibitors	Road Salt
Utility I, MD	1	■		■		■				■
Greenville Utilities Commission, NC	4	■				■			■	
Utility G, NC	5					■				
Utility B, NC	6					■			■	
Utility E, NC	6	■	■			■			■	
Utility D, Nova Scotia	7					■				
Utility K, CA	8						■			
Utility F, ME	9		■							
Utility J, TN	10	■			■			■	■	
Utility H, WA	11									

■ Completed as part of the Water Research Foundation Project 4088

CHAPTER 4
CASE STUDY OF GREENVILLE, NC (COAGULANTS AND ALKALINITY)

Caroline Nguyen, Kendall Stone, and Marc Edwards

Keywords: Coagulants, polyaluminum chloride, alum, orthophosphate, alkalinity, nitrate, passivation, long stagnation

INTRODUCTION

Lead corrosion is sometimes severely impacted by seemingly innocuous changes in water treatment. For example, several utilities observed lead contamination hazards that arose after changing coagulants from aluminum sulfate to ferric chloride or polyaluminum chloride (PACl). Other utilities switched from free chlorine to chloramine disinfection and triggered severe lead leaching to water, such as in Washington, D.C. (Lytle & Schock 2005; Edwards & Dudi 2004).

A recent literature review has documented numerous prior instances in which higher chloride-to-sulfate mass ratio (CSMR) was linked to lead problems (Edwards and Triantafyllidou 2007; Dodrill and Edwards 1995). The chloride-to-sulfate mass ratio is expressed as and can be computed, for example, for water with 10 mg/L Cl and 20 mg/L SO_4:

$$\text{Chloride to Sulfate Mass Ratio (CSMR)} = \frac{\left[Cl^-\right]}{\left[SO_4^{2-}\right]} = \frac{10\text{ mg/L Cl}^-}{20\text{ mg/L SO}_4^{2-}} = 0.5$$

The problems attributable to higher CSMR are manifested through galvanic corrosion of lead pipe:copper or lead solder:copper connections. If alkalinity is low enough, the galvanic corrosion has produced pHs as low as 3.0 at the surface of the lead plumbing material, allowing high lead leaching to persist indefinitely by preventing passivation (Edwards & Triantafyllidou 2007).

The Greenville Utilities Commission (GUC) in North Carolina (NC) has been treating water with aluminum sulfate (alum) with no lead problems. After months of using polyaluminum chloride (PACl) some lead problems were observed. Because PACl has some benefits in terms of particle removal during storm runoff events, the following strategies were tested in an attempt to utilize PACl without detrimental problems from lead. These include:

1) dosing PACl for a very short time period during storm events, and then switching back to alum before problems occur
2) blending alum and PACl coagulants to obtain benefits of the chloride-based coagulant while also maintaining a lower CSMR, and
3) increasing the alkalinity of the water to counter the higher corrosivity while using PACl coagulant.

Bench scale experiments were conducted to examine the above strategies using water from Greenville to: (1) determine the effects of a range of CSMR on lead leaching, (2) evaluate the impact of changes in alkalinity on lead release, (3) identify how quickly lead leaching is worsened following

a coagulant switch from alum to PACl, and (4) evaluate the effectiveness of passivation in reducing lead leaching from solder. To investigate Objective 4, coupons that had been passivated for two years were tested to determine if lead release had been reduced significantly.

In addition to the objectives of the study, other key parameters that affected lead leaching including nitrate and the addition of orthophosphate were identified for this water.

HISTORICAL

The utility receives its potable water from one treatment plant. Sampling events under the US EPA LCR from 1992 to 2001 clearly show that the plant was easily meeting the lead action limit throughout this period (Figure 4.1). However, sampling in 2004 indicated a problem with lead leaching, which was reinforced by two cases of elevated blood lead attributed to lead from potable water in early 2004 (Landers 2006; Allegood 2005; Norman et al. 2005). Tap water from the affected child's faucet measured as high as 400 ppb lead, although lead was more commonly detected from this faucet at 40-60 ppb. The utility's main distribution system does not include lead pipes; thus, the key sources of lead in water are therefore leaded solder and leaded brass.

For the year 2004 about 22% of LCR samples contained lead above the action level. This percentage increased to 27% for the year 2005. The 90th percentile lead concentration was relatively constant at 28-30 ppb in 2004 and 2005.

Like many other utilities across the US, the utility made a series of changes in their treatment process in order to better comply with stringent federal regulations. Theoretically, any of these changes, alone or in combination, could have contributed to the change in the water's aggressiveness to lead. The utility began using chloramines rather than free chlorine as secondary disinfectant in December 2002, in order to comply with US EPA regulations regarding DBP formation. At the same time and due to the introduction of chloramines, finished water pH was increased from about 7.2 to 7.7, in order to optimize monochloramine formation. Later on, in August 2003, the utility also switched from chlorine to ozone as primary disinfectant. Throughout these disinfection changes, the plant continued to follow optimal corrosion control as

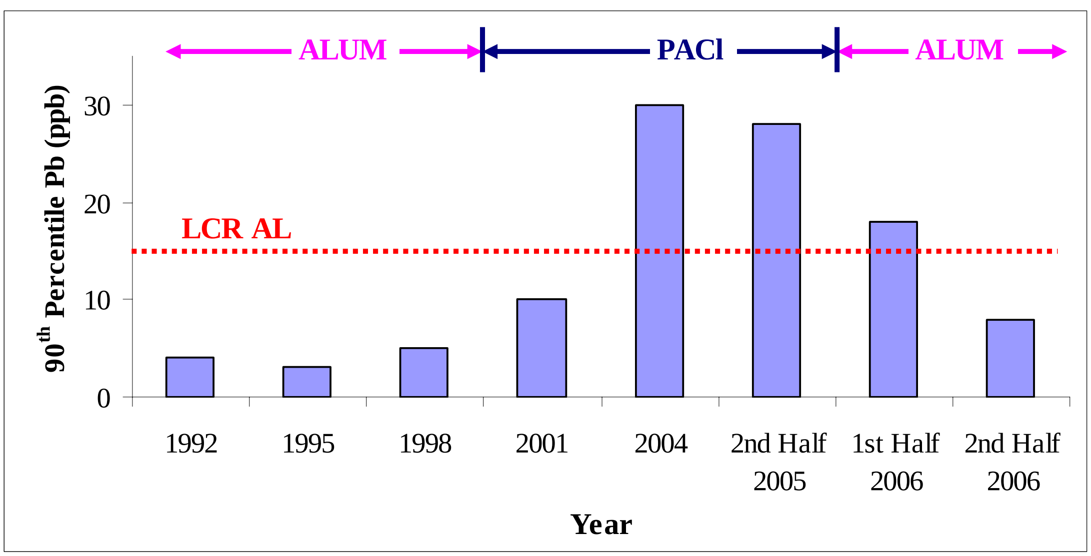


Figure 4.1 Compliance history with the LCR Action Level for lead, for Greenville, NC. Data from Edwards and Triantafyllidou (2007).

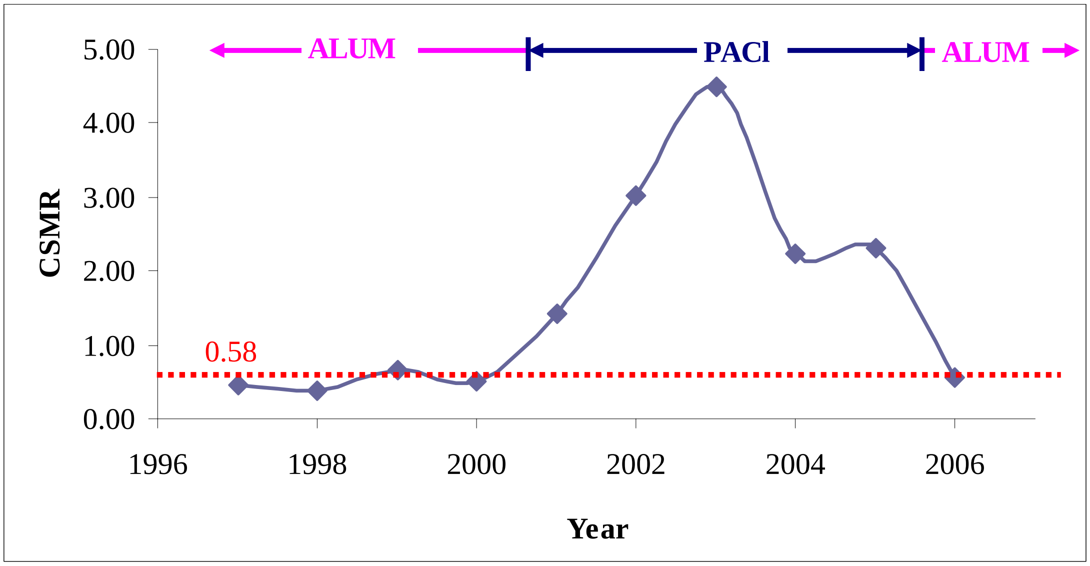


Figure 4.2 Historical plant data of the chloride to sulfate mass ratio in Greenville, NC finished water. The numbers reported are the averages for any given year. Data from Edwards and Triantafyllidou (2007).

required under the LCR using a polyphosphate/phosphate blend. Following exceedence of the LCR action level for lead in August 2004, the plant started dosing an orthophosphate corrosion inhibitor to try to mitigate the lead corrosion problems.

In addition, the plant changed its coagulant from alum (aluminum sulfate) to polyaluminum chloride (PACl) in January of 2001, in order to achieve better organic matter and turbidity removal. The switch resulted in an increase of the CSMR of finished water leaving the treatment plant, as historical data demonstrate (Figure 4.2). This ratio increased well above the threshold of 0.58 mentioned in the Dodrill study, after the coagulant switch (Dodrill and Edwards 1995). More specifically, the CSMR averaged 0.50 for the year 2000 (just before the switch), but increased by a factor of 9X and up to a value of 4.50 during the year 2003 (Figure 4.2).

After considering recommendations from the bench-scale experiments reported in earlier work, the utility switched the coagulation chemical back to alum in April 2006 (Edwards and Triantafyllidou 2007). This change dropped the CSMR to 0.55 (Figure 4.2), and reduced the 90th percentile lead level to 18 ppb (38% reduction) during the first half of 2006 (Figure 4.1). The following LCR sampling event, during the second half of 2006, showed further reduction in the 90th percentile lead level to 8 ppb, which is below the action level (Figure 4.1).

MATERIALS AND METHODS

Test Water

Greenville raw water was shipped to Virginia Tech approximately every other week. Collected water was separated and subjected to simulated drinking water treatment. Treatment involved coagulation, filtration, phosphate corrosion inhibitor addition, disinfection with chloramines, and final pH adjustment. A summary of the treatment scenarios and water chemistry is provided in Table 4.1.

Coagulant Type and CSMR

The two coagulants used were aluminum sulfate (alum) and polyaluminum chloride (PACl). Different levels of chloride-to-sulfate mass ratios (CSMR) were achieved by mixing the two coagulants. The coagulant doses were based on the treatment plant doses. Coagulation mixing speeds and times (rapid mix for one minute, 20 rpm for 20 minutes, and settling for 30 minutes) were selected to simulate to the extent possible the full-scale treatment practice in jar tests.

Alkalinity

The alkalinity for the CSMR test conditions was consistent amongst the treated waters and was approximately 25 mg/L as $CaCO_3$. To determine the effect of increasing alkalinity on lead leaching, five levels of alkalinity were tested for water treated with PACl (Table 4.1). For those conditions, PACl-treated water was diluted to an alkalinity of 20 mg/L as $CaCO_3$ using deionized water to simulate a rain event. The alkalinity for each test condition was then increased to the target level between 20 mg/L as $CaCO_3$ and 40 mg/L as $CaCO_3$ by adding $NaHCO_3$. For the 50 mg/L as $CaCO_3$ alkalinity condition that was evaluated in the earliest stage of this study, $NaHCO_3$ was added to water treated with PACl that had an initial alkalinity of 25 mg/L as $CaCO_3$.

Table 4.1
Test Conditions for Greenville, NC

	Condition	Coagulant	Chloride (mg/L Cl)	Sulfate (mg/L SO_4)	CSMR	Alkalinity (mg/L as $CaCO_3$)	Ortho-phosphate (mg/L P)	Lead Materials Evaluated
CSMR Evaluation	100% Alum	Alum	16	40	0.4	25	1	Passivated solder/copper couples; New solder/copper couples; Brass
	100% Alum, no inhibitor	Alum					0	
	100% PACl	PACl	22	12	1.9		1	
	100% PACl, no inhibitor	PACl					0	
	CSMR Blend	Alum and PACl	21	30	0.7		1	New solder/copper couples; Brass
	CSMR Blend		22	24	1.1			
	CSMR Blend		23	18	1.5			
Alkalinity Evaluation	PACl, 50 mg/L alkalinity (Weeks 1-7)	PACl	23	14	1.6	50	1	New solder/ copper couples; Brass
	PACl, 20 mg/L alkalinity	PACl	21	12	1.9	20	1	New solder/copper couples; Brass
	PACl, 25 mg/L alkalinity					25		
	PACl, 30 mg/L alkalinity					30		
	PACl, 35 mg/L alkalinity					35		
	PACl, 40 mg/L alkalinity (Weeks 8-35)					40		

Corrosion Inhibitor, Disinfectant, and Target pH

Orthophosphate corrosion inhibitor was added to all waters at a dose of 1 mg/L P, except for the two conditions specifically evaluating the effect of no inhibitor (Table 4.1). The target chloramines dose was 3.5 mg/L Cl_2 at a chlorine-to-ammonia ratio of 4:1 mg Cl_2:mg N. The pH was adjusted to the target value of pH 7.7 within 0.1 pH units by bubbling CO_2 to decrease the pH or by adding 0.1 M NaOH to increase the pH prior to exposure of the water to the test coupons.

Lead Plumbing Materials Evaluated

Two common types of lead bearing plumbing materials were evaluated for lead leaching. Brass and 50:50 Pb/Sn solder (new and passivated) were exposed to the water conditions listed in Table 4.1. At least three replicates were tested for each condition to examine statistical confidence of key trends. Water exposed to the lead materials was changed twice per week (Tuesday and Friday) and was otherwise stagnant. All materials were kept at room temperature throughout the testing period.

Passivated Non-Galvanic and Galvanic Solder-Copper Connections

Solder wire pieces (50:50 lead:tin) of 0.125 inch diameter and 0.854 inch height were epoxied to the bottom of a 46 mL vial (Figure 4.3), which was then filled with 25 mL of test water. To simulate the galvanic connection between copper pipe and solder at joints, an identical piece of solder wire was melted onto the inside surface of a copper tube (Figure 4.3). These coupons were used in a prior study for the utility and were allowed to passivate in stagnant water for 2 years prior to the start of this study (Edwards and Triantafyllidou 2007). The coupons exposed to no inhibitor or Zn were used in this study as conditions with no orthophosphate, and the coupons previously used under conditions with orthophosphate or orthophosphate with Zn were grouped as orthophosphate in this study. These aged coupons were evaluated to determine the effect of CSMR during the first 25 weeks of this study. During Weeks 4-6 of the study, a simulated coagulant switch occurred for a short period of time, and a coagulant switch was not re-evaluated later in the study for these coupons.

Figure 4.3 Passivated copper/solder coupons (left) and solder wire (right) were evaluated for effects of CSMR.

New Galvanic Solder-Copper Connections

Simulated lead-copper joints were prepared using a 1-inch in length copper coupling (½-inch diameter copper) with a 1-inch length of 50:50 Pb/Sn solder melted inside (Figure 4.4). The solder-copper couplings were exposed to 100 mL of all water conditions with orthophosphate listed in Table 4.1. After Week 23, the solder-copper coupons exposed to water with a CSMR of 0.7 were then exposed to water treated with 100% PACl (or CSMR 1.9) to determine the length of time PACl could be used before lead leaching increased significantly.

New Brass

Brass coupons (3% lead content) 1/4–inch in diameter were cut in 1-inch length and epoxied to the bottom of glass containers (Figure 4.5). The brass coupons were exposed to 50 mL of all water conditions listed in Table 4.1 for 18 weeks.

Measurements

The study lasted a total of 35 weeks for the new solder-copper coupons, but the brass coupons were evaluated for 18 weeks and the passivated solder coupons for 25 weeks during this study. The evaluation for each material ended once it appeared that the lead levels were stable and the study questions were answered to the extent possible. Composite weekly samples were routinely collected for each water condition (i.e., two water changes collected for each weekly sample) and lead material. The unfiltered composite samples were analyzed for metals with Inductively Coupled Plasma Mass Spectrometry (ICP-MS) in accordance with Standard Method 3125. Datasets in this report are based on averages of lead release from triplicate data during Weeks 17 through 18 for brass and Weeks 22 through 25 for the solder materials. Additionally, initial measurements of lead from the passivated coupons were collected after 2 years stagnation prior to the start of this study.

Figure 4.4 New copper/solder couples were exposed to water to compare effects of CSMR and alkalinity.

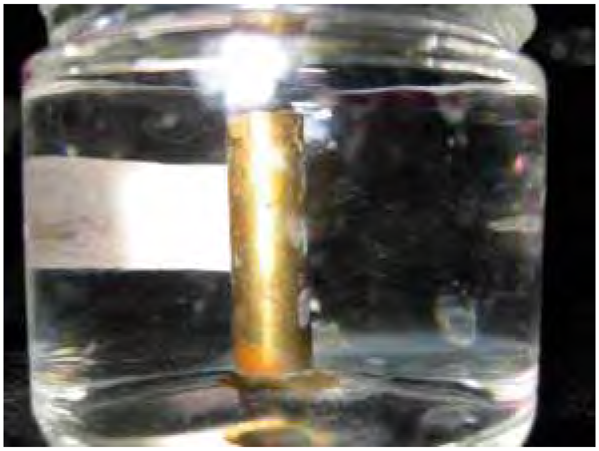


Figure 4.5 Brass coupon epoxied to glass and exposed to water.

RESULTS AND DISCUSSION

Effect of Coagulant Change

A key question for this study was: "How long could the utility switch from alum to PACl before lead levels would substantially increase?" The coupons used to evaluate this question were new solder-copper coupons, and a simulated coagulant switch occurred after Week 24 of the study. Throughout the first 24 weeks of testing, the 100% alum (CSMR of 0.4) and CSMR 0.7 conditions were not statistically different in terms of lead leaching and leached low relatively lead (Figure 4.6). These coupons were then abruptly exposed to 100% PACl (CSMR of 1.9) after Week 24 to simulate a switch, and to see how long it would take for lead leaching to worsen. Some coupons exposed to 100% PACl or 100% alum throughout the entire study period were used as a comparison (Figure 4.7).

Lead leaching from new solder-copper coupons that had been previously exposed to low CSMR water and leached low lead, began increasing after 2 weeks of exposure to 100% PACl-treated water (Figure 4.7). After the 3rd week of exposure to the higher CSMR water, the coupons previously exposed to CSMR 0.7 water had significantly higher lead release than the 100% alum condition (p-value < 0.05). In fact, the alum-treated water exhibited a decrease in lead release from 61 ppb to 37 ppb after week 24 while the coupons switched to 100% PACl had increased in the amount of lead in water from 298 ppb to 485 ppb after the coagulant switch (Figure 4.8). Even after 2.5 months of exposure to 100% PACl-treated water, the coupons (that were previously exposed to the CSMR 0.7 condition) reached only about 10% of the lead leaching of the coupons that were exposed to 100% PACl for the entire 35-week duration of the study. The results prove that it takes some time before coupons that were passivated begin to show higher lead leaching when exposed to higher CSMR.

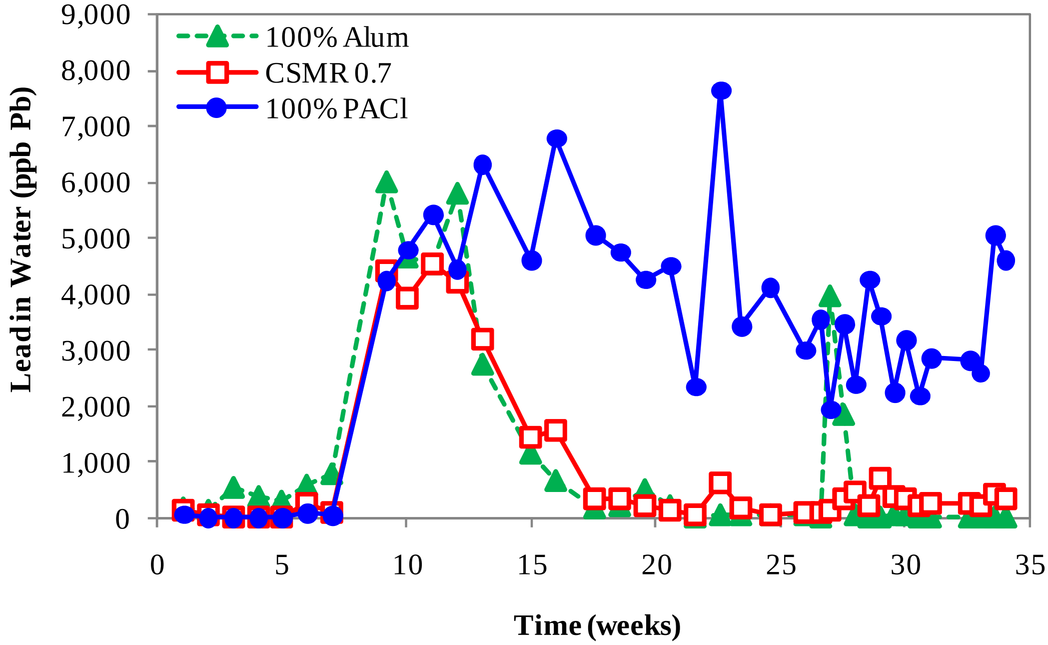


Figure 4.6 Lead release as a function of time for 100% alum (CSMR 0.4), 100% PACl (CSMR 1.9), and CSMR 0.7 conditions throughout the entire testing period. Samples were exposed to water with nitrate from week 7 to week 12, causing a short-term spike in lead.

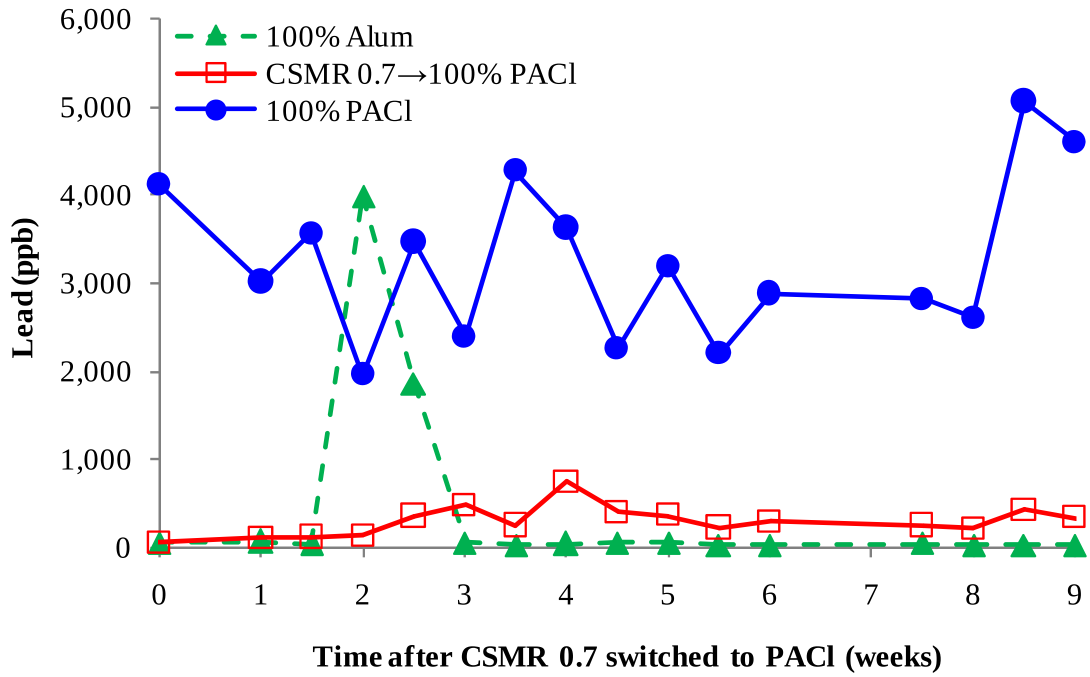


Figure 4.7 Lead release over time following a change to 100% PACl coagulant (CSMR 1.9) from a blended coagulant with a CSMR of 0.7. The 100% alum (CSMR 0.4) and PACl conditions in the plot were exposed to the coupons since the start of the study, or for 23 weeks prior to the coagulant changeover.

Effect of Blended Alum and PACl Coagulants on Lead Levels

New Solder-Copper Coupons

To obtain the benefits of PACl coagulant while maintaining a lower CSMR, one option for the GUC was to use a blend of PACl and alum coagulants. Consistent with theory and similar to the results for the passivated solder-copper coupons with no inhibitor after regular water changes, CSMR had a direct positive correlation with lead release from new lead solder-copper coupons in this water with 1 mg/L PO_4-P (Figure 4.9). For instance, alum-treated water had the lowest lead release, and increasing the CSMR from 0.4 to 0.7 resulted in approximately 60% higher levels of lead (Figure 4.10). Increasing the CSMR to approximately 1.1 resulted in 25 times more lead in the water compared to alum-treated water with a CSMR of 0.4. Furthermore, at the highest CSMR level evaluated in this study (100% PACl), the lead concentrations were 50 times higher than the lowest CSMR condition (100% alum). The results were shown to be statistically significant (p-value < 0.05), except the comparisons between the two lowest CSMR test conditions and between the two highest CSMR test conditions. Therefore, these results suggest that higher blends of PACl with alum increases lead release, but the blended coagulant with a CSMR of 0.7 was not significantly different from the 100% alum condition and could be used by the utility without markedly increasing the lead in water.

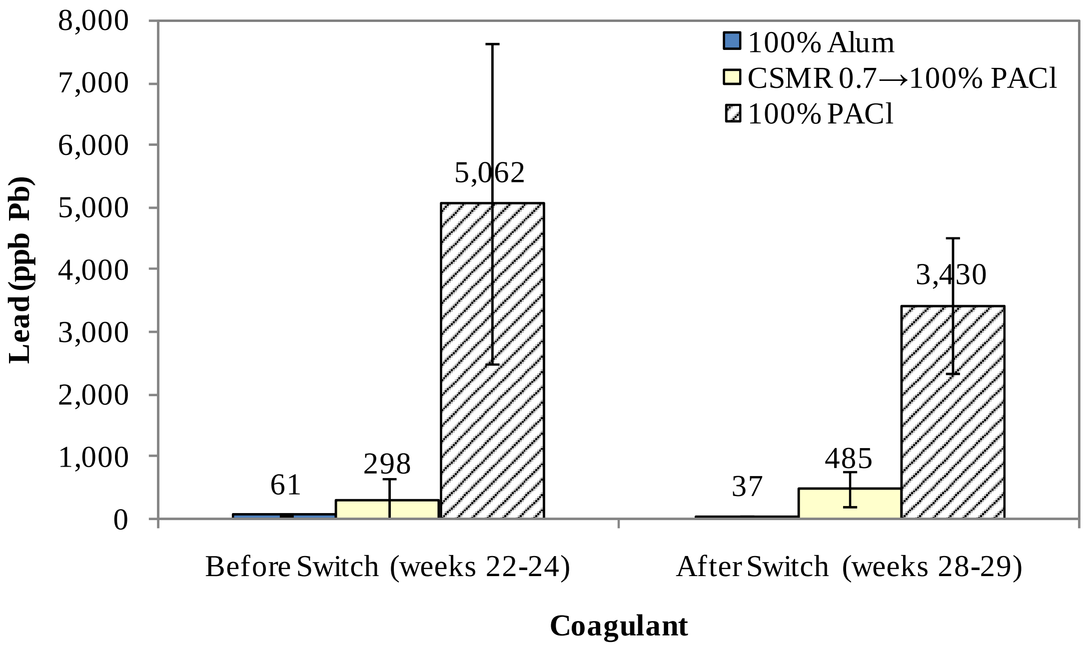


Figure 4.8 Lead release from coupons exposed to CSMR 0.7 water before and after switching the condition to 100% PACl. The 100% alum (CSMR 0.4) and 100% PACl (CSMR 1.9) conditions are shown for comparison. After switching lead levels increased, but the increase took several weeks to become significant.

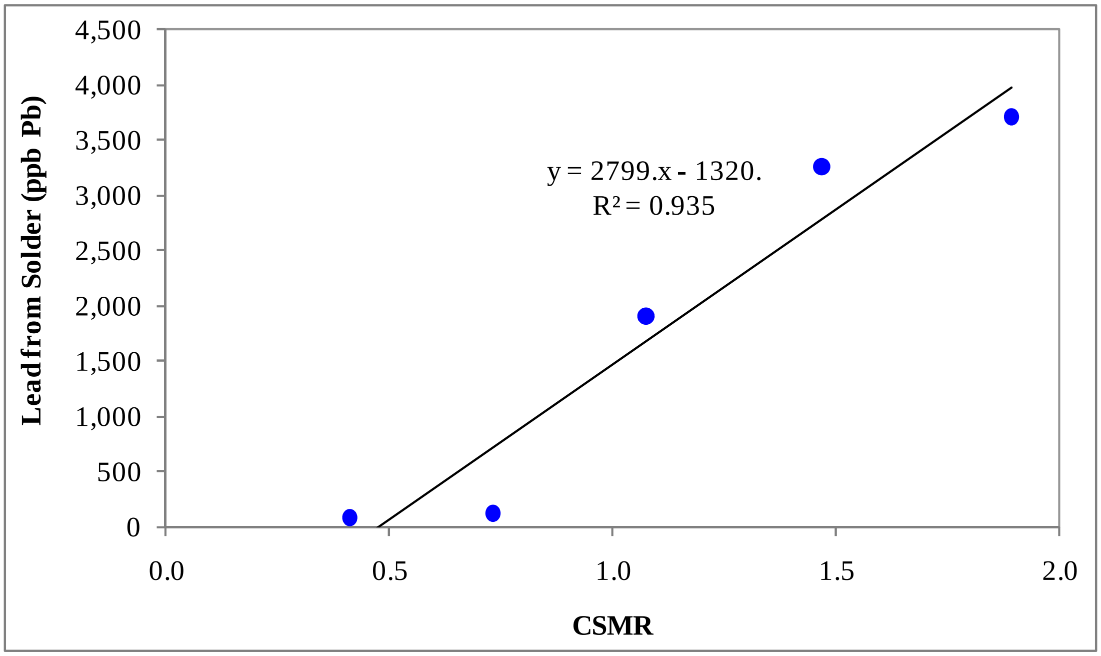


Figure 4.9 Lead release from solder as a function of CSMR at week 23.

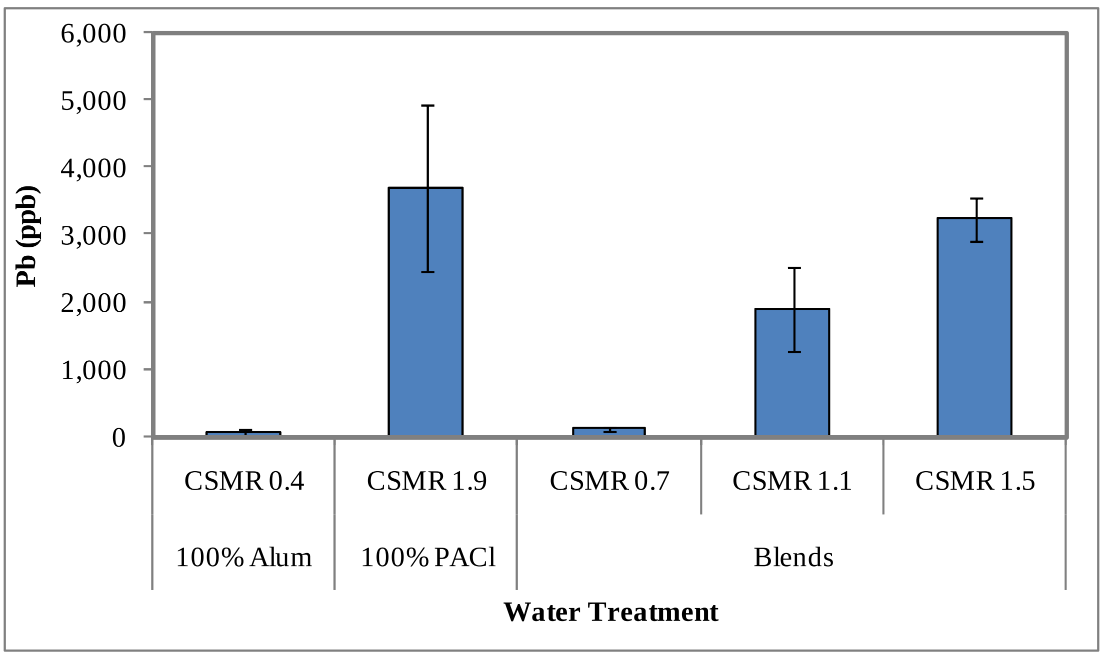


Figure 4.10 Lead release from new galvanic solder-copper coupons for a range of CSMRs during Weeks 22 and 23. Two replicate lead data points for CSMR 1.5 were discarded because the values (>8,800 ppb Pb) were more than 2.5 times the average for the condition.

Brass

T-testing indicated that there were no significant differences in lead leaching among the CSMR levels (Figure 4.11).

Effect of Alkalinity in High CSMR Water

New Solder-Copper Coupons

There was no conclusive evidence that increasing alkalinity reduced lead leaching from coupons exposed to 100% PACl-treated water (Figure 4.12). T-testing with a Bonferroni correction indicated that there were no significant differences between any of the conditions. Initially in this study, there was evidence suggesting that higher alkalinity significantly reduced lead leaching. For example, PACl-treated water with an alkalinity of 50 mg/L as $CaCO_3$ had 88% less lead than PACl-treated water with 25 mg/L as $CaCO_3$, and the result was significant at the 95% confidence level (Figure 4.13). However, after Week 7 nitric acid (nitrate) was added to all of the alkalinity test waters to consistently reduce the alkalinity and resulted in increased lead leaching.

Brass

Brass did not appear to be greatly affected by changes in alkalinity (Figure 4.14). T-testing with the Bonferroni correction indicated that there were no significant differences between any of the conditions.

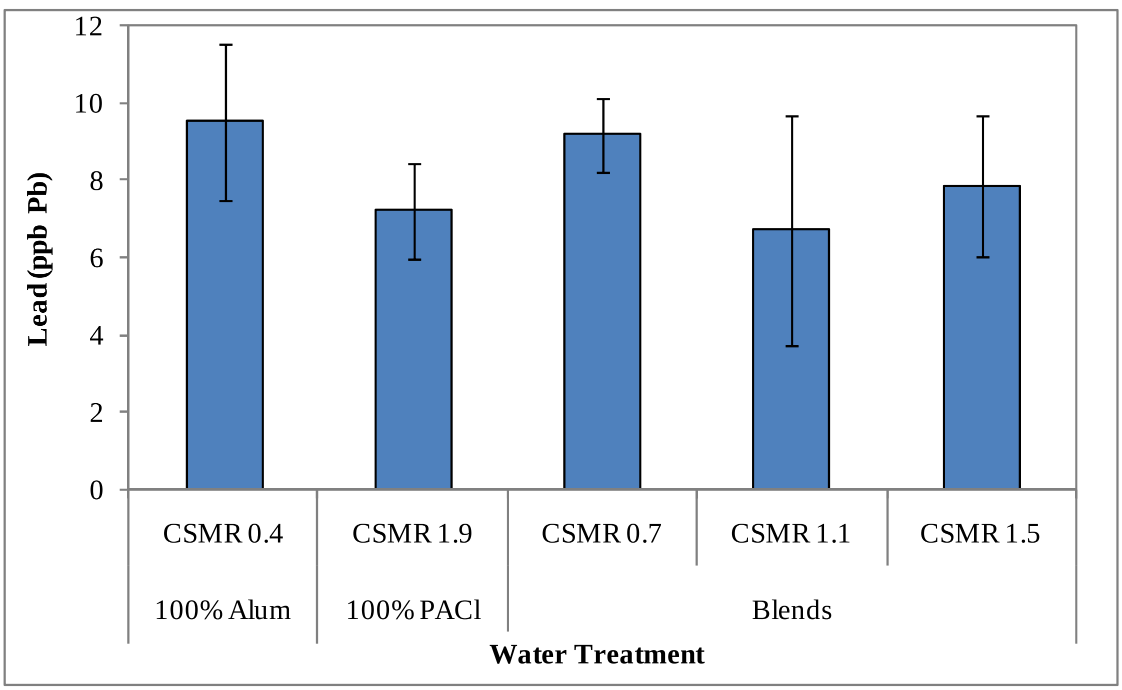


Figure 4.11 Lead release from brass for a range of CSMRs during Weeks 17 through 20. Error bars represent 95% confidence intervals among the replicates for each condition for the sampling period.

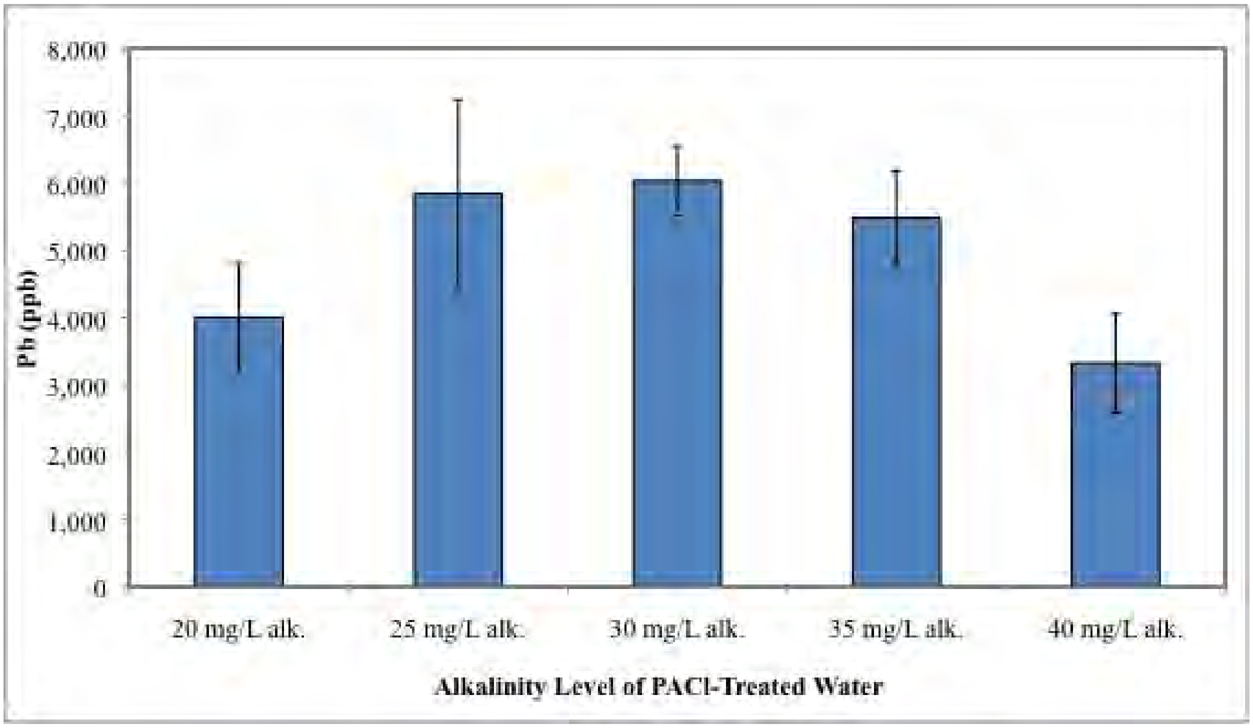


Figure 4.12 Effect of alkalinity on lead leaching from new solder-copper coupons. Error bars show 95% confidence intervals.

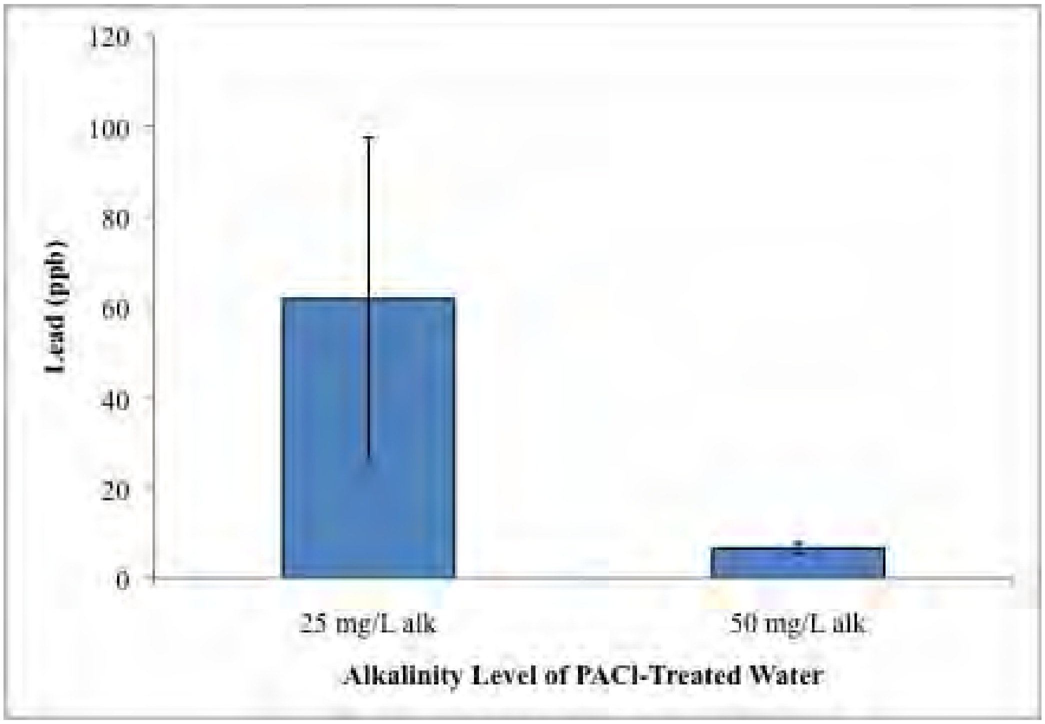


Figure 4.13 Effect of increasing alkalinity from 25 mg/L to 50 mg/L as $CaCO_3$ before coupons were exposed to nitrate.

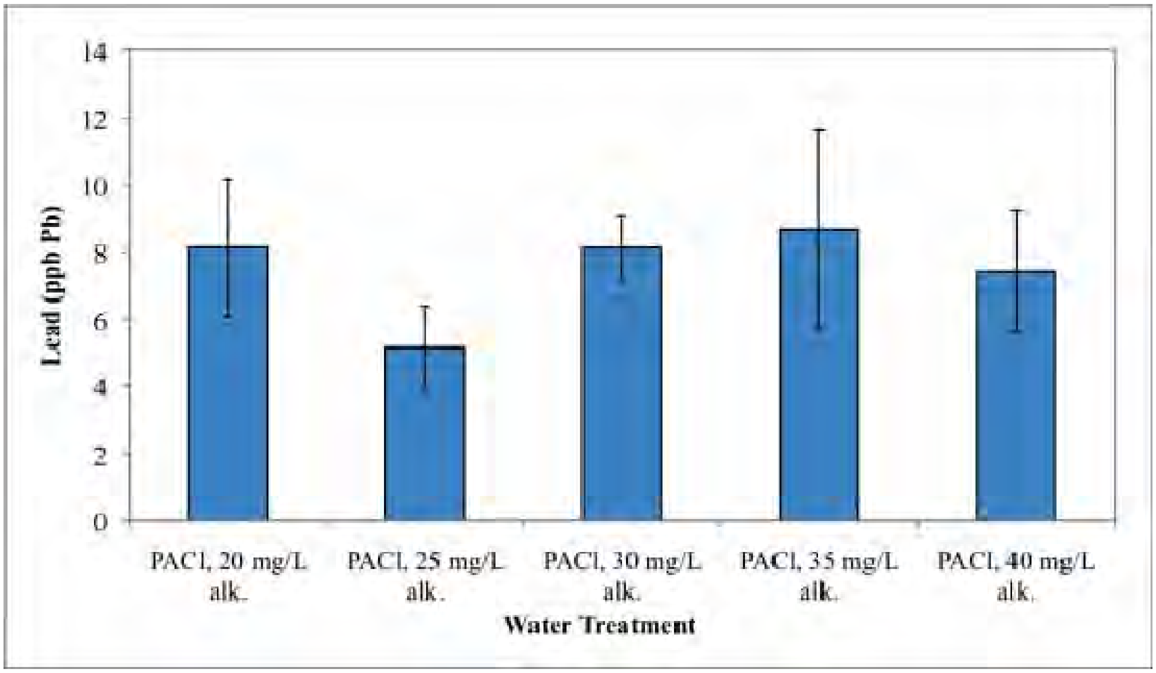


Figure 4.14 Effect of alkalinity on lead leaching from brass coupons. Error bars show 95% confidence intervals.

Impact of Nitrate

The coupons used to evaluate the effects of alkalinity were exposed for at least 5 weeks to a high level of nitrate (5 mg/L NO_3-N) when nitric acid was dosed to decrease the alkalinity to levels between 0 and 20 mg/L as $CaCO_3$ in the earliest stage of the study. For this water, even a low level of nitrate could increase lead release. For instance, the coupons originally exposed to 50 mg/L alkalinity as $CaCO_3$ were later exposed to water containing nitrate when the alkalinity was decreased to 40 mg/L as $CaCO_3$, and the lead release increased more than would be expected with an alkalinity decrease of 10 mg/L as $CaCO_3$ (Figure 4.15). An additional study was conducted to examine the effect of nitrate on lead leaching and demonstrated that nitrate dramatically increases lead release (Stone et al. 2009). No phosphate was added to the waters in the additional study, and consistent with prior experiences with copper pipe in those situations, no nitrite was detected, and there was no evidence of nitrification. Moreover, the pH of the bulk water did not drop as would occur with nitrification.

The surface of the solder coupon was irreversibly damaged by the presence of nitrate in the early stage of this case study. Increasing the alkalinity from 25 mg/L to 50 mg/L as $CaCO_3$ had no beneficial effects on lead leaching in the water with nitrate (Figure 4.16), in contrast to the initial results before the coupons were exposed to nitrate (Figure 4.13). At this time, the mechanism of the nitrate corrosive attack is unknown, and additional research on this issue is underway.

In practice, nitrate can increase in a water supply via a variety of methods. In distribution systems where nitrification occurs, nitrate in the range of 1 mg/L can be formed from ammonia. Heavy use of nitrogen fertilizers has caused increasing amounts of nitrate to enter some water supplies via runoff (Schlesinger et al. 2006). Regardless of cause(s), higher levels of nitrate deserve increased scrutiny relative to lead leaching from old 50:50 Pb/Sn solder.

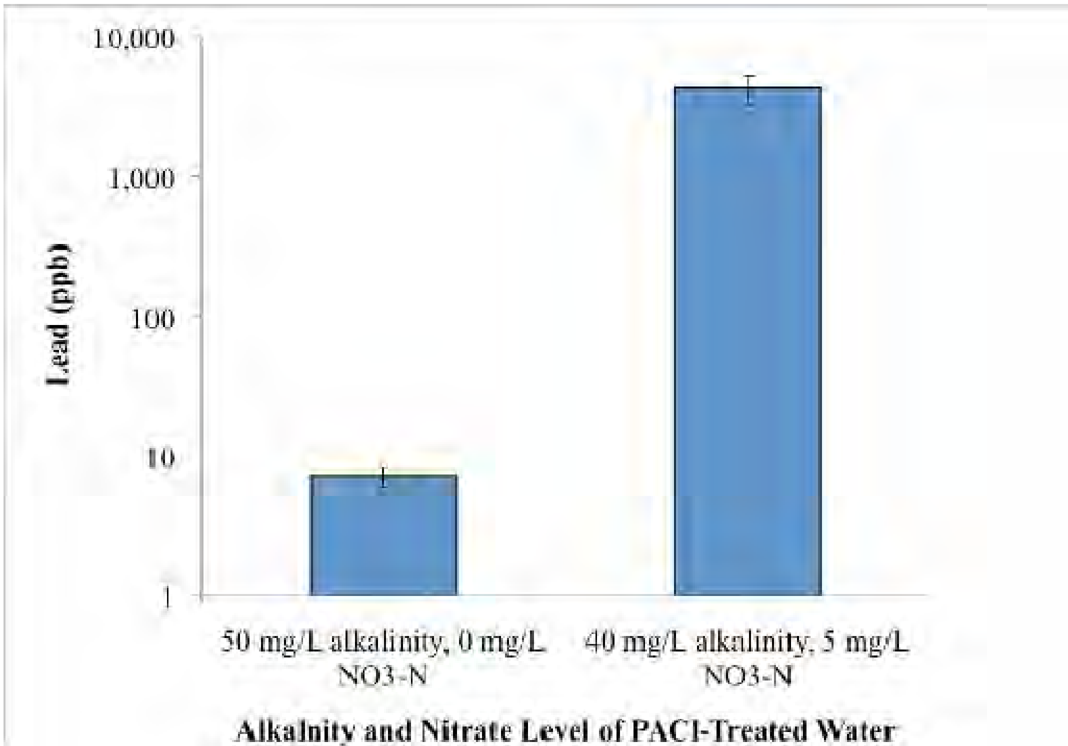


Figure 4.15 Effect of nitrate on lead leaching from coupons exposed to high alkalinity waters (log scale). The error bars represent the 95% confidence intervals.

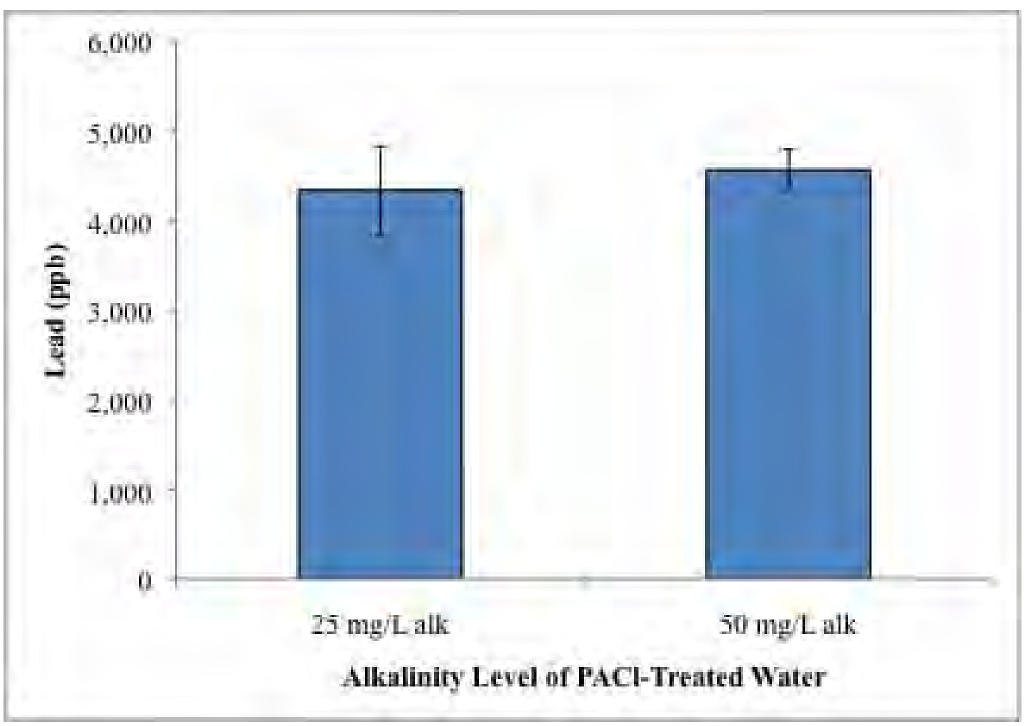


Figure 4.16 Effect of increasing alkalinity from 25 mg/L to 50 mg/L as $CaCO_3$ on lead leaching at the end of the study. The error bars represent 95% confidence intervals.

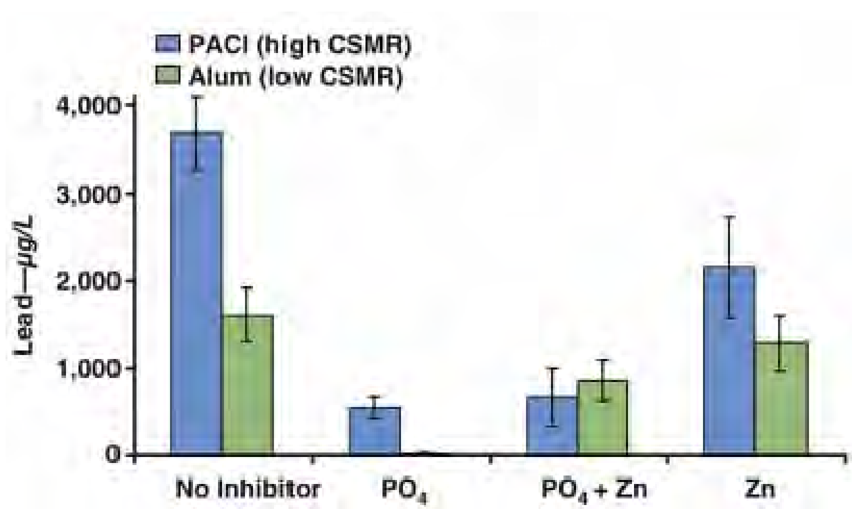
Effect of CSMR after Long Stagnation Period

We were curious what would happen to lead levels in a sample exposed to various CSMR and inhibitor levels for a very long stagnation time. The passivated coupons in this study were last used in 2006 and were stored in their respective target waters for 2 years without further water changes (Edwards and Triantafyllidou 2007). At the end of the study in 2006, PACl was shown to be much worse than alum in terms of lead leaching for 48-hour stagnation events, except in the case where zinc orthophosphate was dosed. Orthophosphate addition reduced the lead levels (Figure 4.17).

When the study was resumed in 2008, the water that had stayed stagnant for 2 years was collected and analyzed for lead. The results indicated that all of the samples were contaminated with very high levels of lead regardless of CSMR (Figures 4.18 and 4.19). The only exception was alum-treated water with orthophosphate, which had very low lead (Figure 4.18).

Orthophosphate reduced the lead release for alum-treated water (p-value < 0.03) but did not reduce lead leaching from PACl-treated water (p-value = 0.35) when exposed to solder-copper coupons in stagnant water for 2 years. Although t-testing indicated that the conditions were not statistically different based on the replicate data, PACl dosed with orthophosphate did leach as much as 3 times more lead than PACl with no inhibitor.

Additionally, the replicate with the highest lead leaching that was exposed to alum treated water with no orthophosphate leached 12,000 ppb Pb to the water during the 2-year period of stagnation, which was twice the amount of lead from the worst coupon treated with PACl and no inhibitor. Overall, the alum and PACl conditions without orthophosphate were not statistically different, and the results suggest that the CSMR of the water had no effect on lead leaching for galvanic lead solder following a very long period of stagnation.



Source: Edwards and Triantafyllidou, 2007.

Figure 4.17 Lead release vs. corrosion control treatment for galvanic solder, in PACl-treated water and alum-treated water, averaged from Weeks 5 to 9 of the previous study (Edwards et al., 2007). The error bars denote 95% confidence intervals.

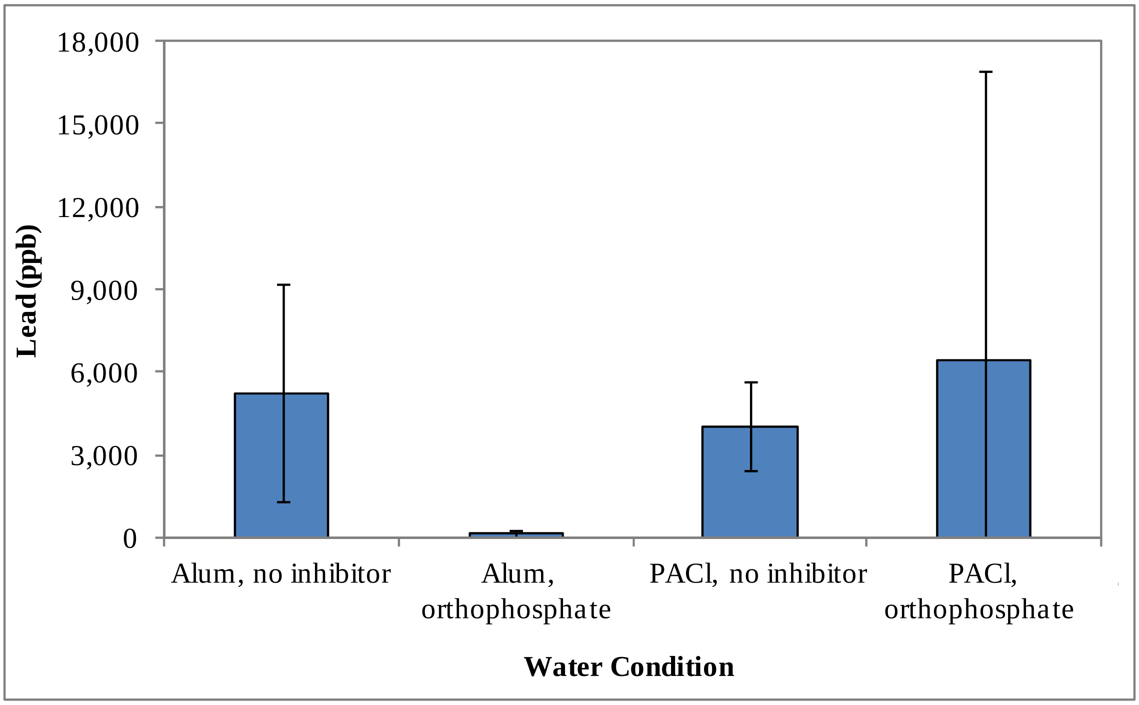


Figure 4.18 Lead concentrations in water after 2 years of stagnation for the passivated solder-copper coupons.

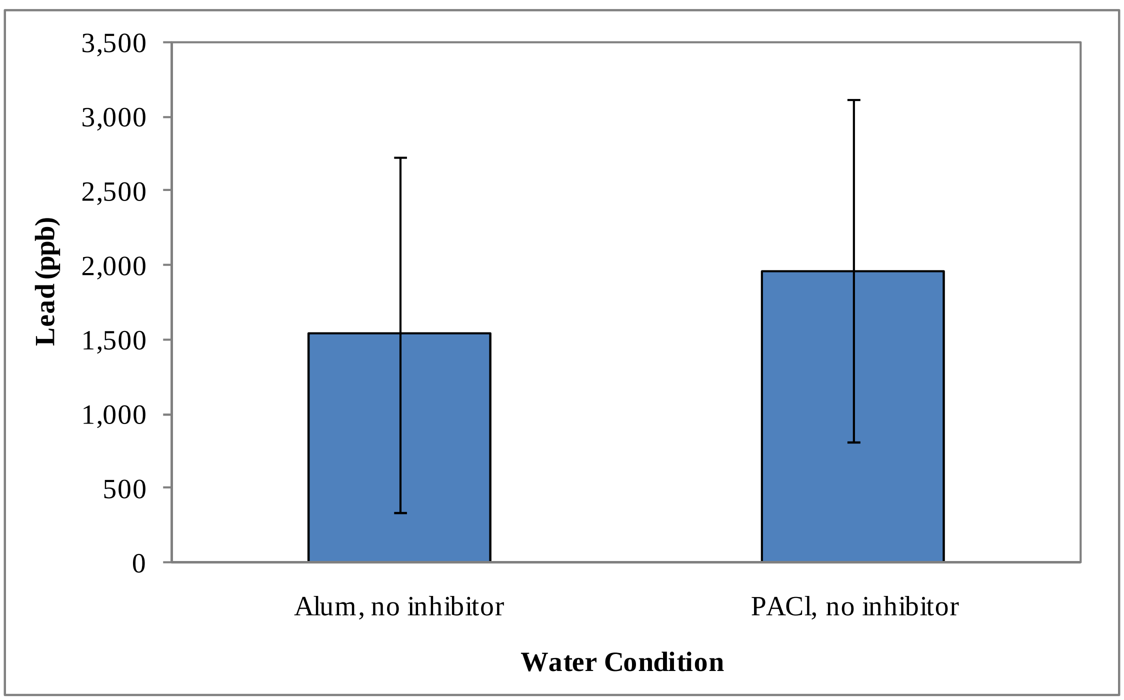


Figure 4.19 Lead concentrations in water after 2 years of stagnation for the passivated solder (no connection to copper).

Effect of CSMR on Passivated Coupons after Regular Water Changes

The tests described in Figure 4.18 were continued with regular water changes in order to see if trends of CSMR on lead leaching would be resumed. After several weeks of regular water changes and collecting water from the passivated coupons, the lead leaching gradually decreased to levels that were approximately 50% of the lead levels in the previous study three years ago (Figure 4.20 and Table 4.2). The coupons exposed to orthophosphate had the lowest lead levels. Furthermore, the only condition that was unchanged compared to the lead levels 3 years ago was the PACl treated water that contained no orthophosphate (Table 4.2).

When there was no orthophosphate in the water, the CSMR had a large impact on lead leaching. There was 4 times more lead in PACl-treated water, which had approximately 3,800 ppb Pb, than in alum-treated water, which had approximately 950 ppb Pb (Figure 4.20).

In contrast, orthophosphate was effective in reducing lead leaching from passivated solder-copper coupons (p-value < 0.01), and CSMR had no statistically significant effect on the passivated coupons when orthophosphate was present, which is contrary to results for new solder exposed to orthophosphate. For passivated solder galvanically connected to copper, the addition of orthophosphate dramatically decreased the lead leaching by 3.5 times for alum-treated water and 16 times for PACl treated water (Figure 4.20). Therefore, passivated solder-copper coupons exposed to orthophosphate were not affected by the CSMR.

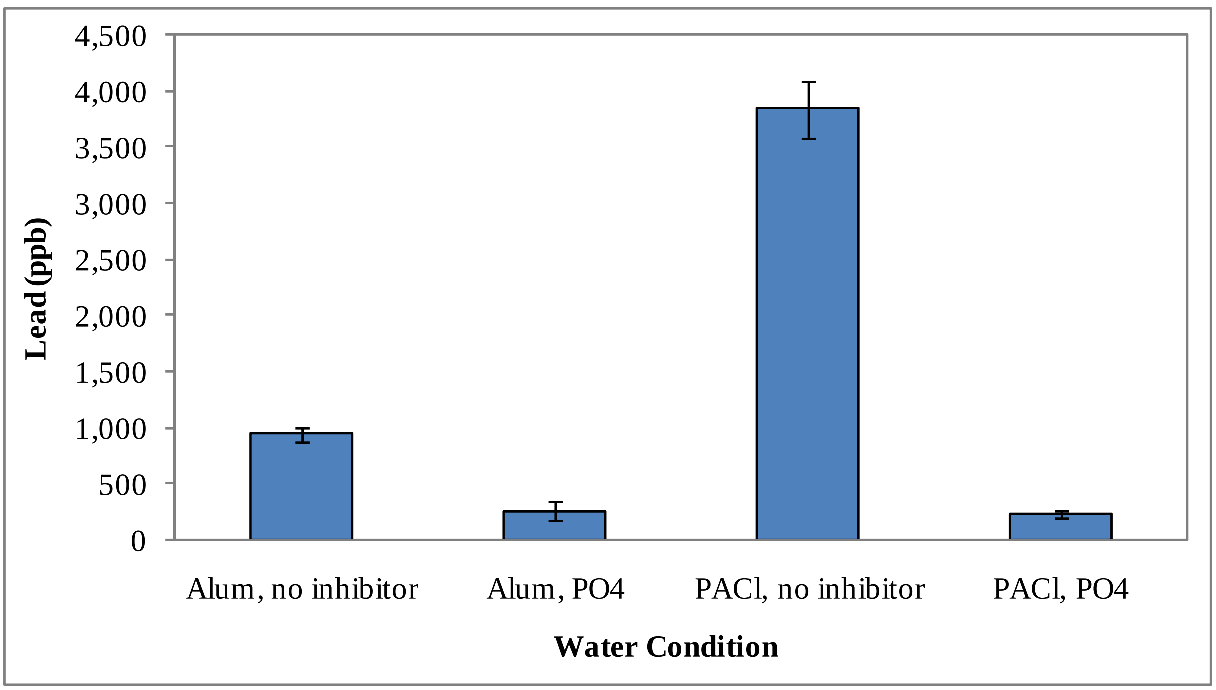


Figure 4.20 Lead release from coupons aged 2 years, and then exposed to alum or PACl coagulants with or without orthophosphate during Weeks 22 through 25. Error bars show the 95% confidence intervals.

Table 4.2
Comparison of average lead released from the aged solder during the first study in 2006 (Edwards and Triantafyllidou 2007) and in this study in 2009. The 2009 values are based on averages of Weeks 22-25 of this study.

Condition and Treatment Type		**Lead Concentration** (ppb Pb)	
		2006	***2009***
Galvanic solder	Alum, no inhibitor	1,460	950
	Alum, orthophosphate	440	260
	PACl, no inhibitor	2,930	3,800
	PACl, orthophosphate	610	240
Non-galvanic solder	Alum, no inhibitor	270	100
	PACl, no inhibitor	230	120

Effect of Galvanic Connection on Passivated Solder

Solder-copper coupons and solder (not connected to copper) that were used in the previous study in 2006 were stagnant in water for 2 years and then used in this study. The galvanic connection of passivated lead solder to copper markedly increased lead leaching compared to lead solder alone. For instance, by connecting the solder to copper, the lead leaching increased 9 times for alum treated water and 31 times for PACl treated water (Figure 4.21). Furthermore, when solder was alone in water, the coagulant type (and CSMR) did not have a significant effect on lead leaching at the 95% confidence level. Therefore, the results support previous theory that the effect of CSMR is dominated by galvanic corrosion (Edwards and Triantafyllidou 2007) and that the effects continue for years.

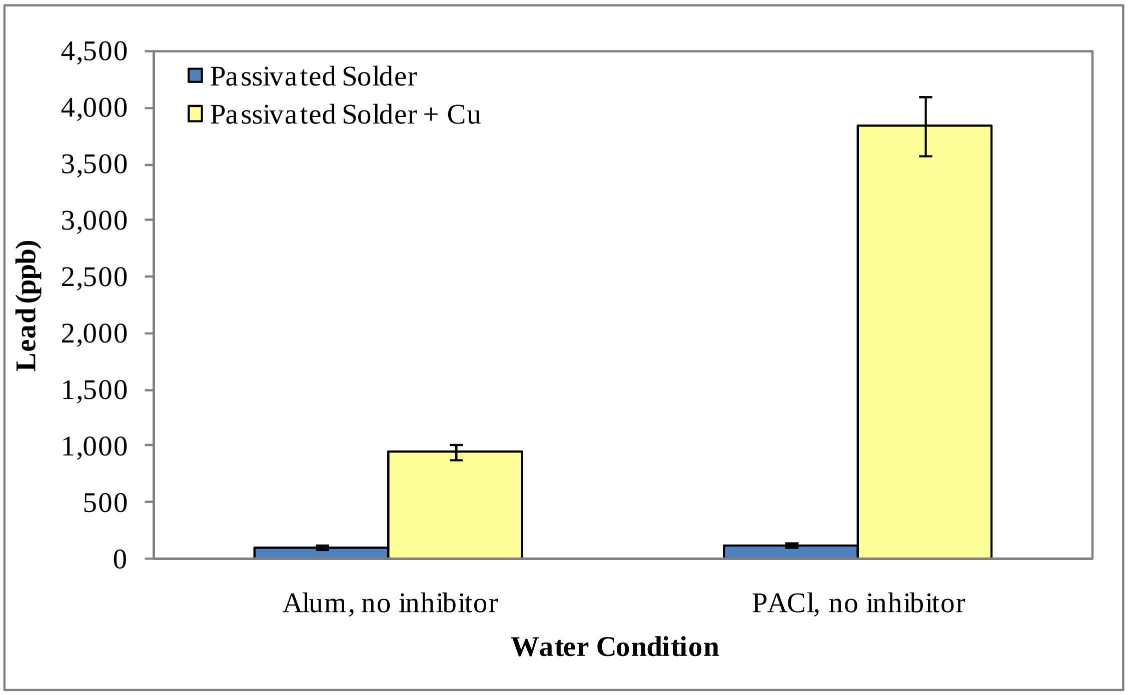


Figure 4.21 Lead release from passivated solder, which were passivated for 2 years, as a result of connection to copper during Weeks 23-25 of this study. Error bars show 95% confidence intervals.

FUTURE WORK

Alkalinity

To determine the effect of alkalinity on lead leaching in PACl-treated water without complications of nitrate, a new test with new coupons will be conducted. The evaluation is currently in-progress.

CONCLUSIONS

- For this water, higher CSMR and higher levels of nitrate in the water dramatically increased the lead release from solder galvanically connected to copper.
- In the simulation where the coagulant was switched from alum to PACl, it took approximately 2 weeks for the lead leaching to increase from new solder-copper coupons.
- After 2 years of stagnation, the only condition that had low lead leaching was the condition with orthophosphate and low CSMR water.
- Passivated coupons had reduced lead levels compared to results from 3 years ago, except for the condition with PACl and no orthophosphate, which sustained high levels of lead leaching.
- The results in this study in relation to effects of alkalinity were not conclusive; therefore, a range of alkalinities will be re-evaluated with new solder-copper coupons.

CHAPTER 5
CASE STUDY OF UTILITY G, NC (COAGULANTS)

Caroline Nguyen, Kendall Stone, and Marc Edwards

Keywords: Coagulants, ferric chloride, ferric sulfate, alum, ferric sulfate polymer blend, ferric sulfate / aluminum chlorohydrate blend

INTRODUCTION

Bench scale experiments were conducted for five weeks to study the effects of coagulant selection on lead leaching in water for Utility G in North Carolina. Within the last few years, Utility G has implemented four different coagulants with varying chloride and sulfate content, and high 90th percentile lead in the system has coincided with times when chloride-based coagulants were used. Therefore, five different types of coagulants (including one prospective coagulant) in treated waters were compared head-to-head in terms of lead leaching from brass (5% lead content) and 50:50 Pb/Sn solder galvanically connected to copper. These lead materials are assumed to be present in the distribution systems throughout the county at some level of occurrence. The goal was to determine whether the coagulants that contributed chloride to the water, definitively increased lead leaching, versus those that contribute sulfate to the water.

MATERIALS AND METHODS

Test Water

Utility G water was shipped to Virginia Tech approximately every other week. Collected water was separated and subjected to simulated drinking water treatment, which was otherwise identical except for the type of coagulant used. Treatment involved coagulation, filtration, phosphate corrosion inhibitor addition, disinfection with chloramines, and final pH adjustment. A summary of the treatment scenarios and water quality information is provided in Table 5.1. The alkalinity of the water was approximately 40 mg/L as $CaCO_3$.

Table 5.1
Chloride and Sulfate Concentrations after Indicated Water Treatment

Coagulant Type	Chloride (mg/L Cl)	Sulfate (mg/L SO_4)	CSMR
Aluminum sulfate (alum)	14	32	0.4
Ferric chloride	28	9	3.1
Ferric sulfate / aluminum chlorohydrate blend	18	10	1.8
Ferric sulfate	13	30	0.4
Ferric sulfate polymer blend	14	32	0.4

Coagulant type

The five types of coagulation treatment evaluated were: (1) aluminum sulfate, (2) ferric chloride, (3) a ferric sulfate / aluminum chlorohydrate blend, (4) ferric sulfate, and (5) a ferric sulfate polymer blend. Utility G has used the first four over the last couple of years, and the ferric sulfate polymer blend is a coagulant that is being considered for future use.

The ferric sulfate coagulant dose was provided by the utility, and mixing speeds and times (rapid mix for one minute, 20 rpm for 20 minutes, and settling for 30 minutes) were selected to simulate to the extent possible the full-scale treatment practice in jar tests. The coagulant doses for ferric chloride and aluminum sulfate were based on the total molar dose of ferric (mol/L Fe^{3+}) that the treatment plant used. For instance, if 1 mol/L Fe^{3+} was dosed at the plant, 1 mol/L Fe^{3+} was also used for the ferric chloride condition, and 1 mol/L Al^{3+} was dosed during coagulation for aluminum sulfate (alum). The doses of the ferric sulfate blends were based on the manufacturer's recommendations. The final chloride and sulfate concentrations in the treated water are listed in Table 5.1 for each coagulant condition, and the removal of natural organic matter (NOM) from the water after coagulation/sedimentation and filtration is listed in Table 5.2 for each of the coagulants.

Corrosion Inhibitor, Disinfectant, and Target pH

The dose of orthophosphate for this study was 1 mg/L as P. The target free chlorine disinfectant dose was 2.5 mg/L Cl_2. The pH was adjusted to the target value of pH 7.3 within 0.1 pH units with either 0.1 M NaOH or 0.1 M HNO_3 prior to exposure to the test coupons.

Evaluated Lead Plumbing Materials

Two common lead bearing plumbing materials were evaluated for impacts on lead leaching. Brass and 50:50 Pb/Sn solder were exposed to the water conditions listed in Table 5.1. Three replicates were tested for each condition to examine statistical confidence of key trends. Water exposed to the lead materials was changed twice per week (Monday and Thursday) and was otherwise stagnant. All materials were kept at room temperature throughout the testing period.

Solder

Simulated lead-copper joints were prepared using a 1-inch in length copper coupling (½-inch diameter copper) with a 1-inch length of 50:50 Pb/Sn solder melted inside (Figure 5.1). The solder-copper couplings were exposed to 100 mL of all water conditions listed in Table 5.1.

Brass

Brass coupons (5% lead content) that were ½–inch in diameter were cut in 0.4-inch lengths and epoxied to the bottom of glass containers (Figure 5.2). The brass coupons were exposed to 50 mL of all water conditions listed in Table 5.1.

Table 5.2
Water Quality during Water Treatment for Utility G

Coagulant Type	**TOC *** (mg/L C)		**UV254 Absorbance **** (cm^{-1})		**Turbidity ***** (NTU)	
	After Settling	*After Filtration*	*After Settling*	*After Filtration*	*After Settling*	*After Filtration*
Aluminum sulfate (alum)	1.8	1.7	0.053	0.038	3.0	1.0
Ferric chloride	1.5	1.3	0.076	0.027	1.7	0.3
Ferric sulfate / aluminum chlorohydrate blend	2.8	1.9	0.112	0.055	5.4	2.0
Ferric sulfate	1.6	1.3	0.072	0.034	1.9	0.6
Ferric sulfate polymer blend	1.7	1.4	0.078	0.027	2.1	0.2

* Raw water = 2.88 mg/L total organic carbon.
** Raw water = 0.137 cm^{-1}.
*** Raw water = 13 NTU.

Measurements

Composite weekly samples were routinely collected for each water condition (i.e., two water changes collected for each weekly sample) and lead material. The samples were acidified with 2% HNO_3 for at least 24 hours to dissolve metals. The unfiltered composite samples were analyzed for metals with Induced Coupled Plasma Mass Spectrometry (ICP-MS). The results for brass in this report were from the entire study period since the lead remained relatively low and constant during the 5 weeks. Results for solder were from the last three weeks of the study since the lead levels changed dramatically with time.

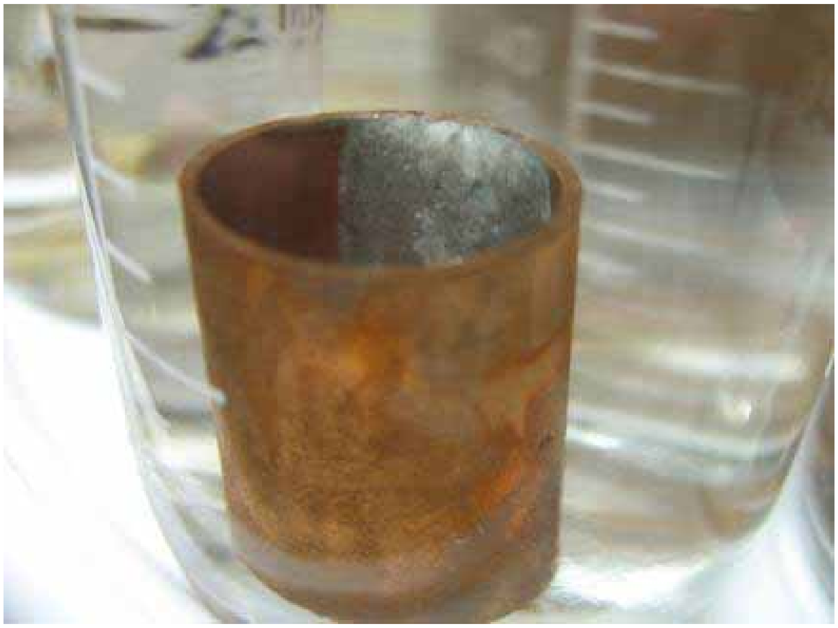


Figure 5.1 Solder-copper coupon for Utility G

Figure 5.2 Brass coupon (5% lead content) for Utility G in glass vial

RESULTS AND DISCUSSION

Effect of CSMR

Water with low CSMR (i.e., treated with alum, ferric sulfate, or the ferric sulfate polymer blend) consistently had lower lead leaching from solder. Treating water with coagulants containing chloride (including the ferric sulfate aluminum chlorohydrate blend) resulted in the highest lead release from solder (Figure 5.3). Brass, which contained 5% lead, did not appear to be affected as strongly by the CSMR.

Brass

Lead leaching from brass was similar for all of the tested water conditions (Figure 5.4). There were no significant differences among the test conditions based on statistical t-tests. For this utility, brass is not a problem in terms of lead leaching.

Solder

Consistent with theory and practical experience at this utility, lead leaching from 50:50 Pb/Sn solder galvanically connected to copper was affected by the CSMR of the water. The ranking from least to worst lead leaching was: (1) ferric sulfate, (2) alum or the ferric sulfate polymer blend, (3) ferric chloride or the chlorohydrate blend. Therefore, after exposure to solder, ferric sulfate-treated water resulted in the lowest lead leaching. The other sulfate-based coagulants (alum and the ferric sulfate polymer blend) also had significantly less lead released than the chloride-based coagulants (ferric chloride and ferric sulfate/aluminum chlorohydrate

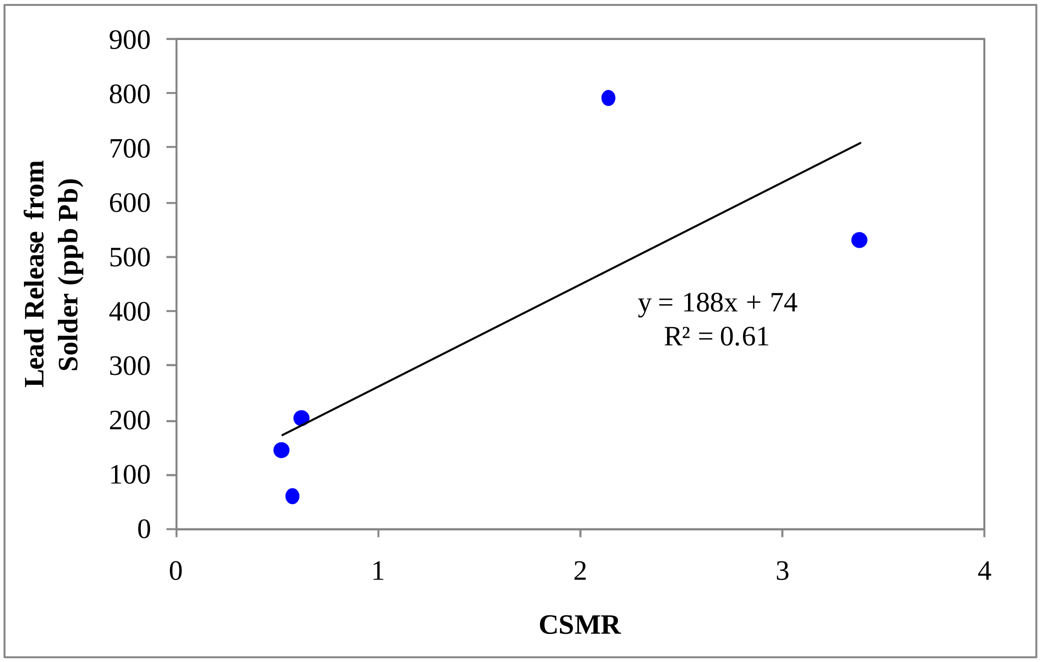


Figure 5.3 Lead leaching from solder as a function of the chloride-to-sulfate mass ratio (CSMR) for Utility G

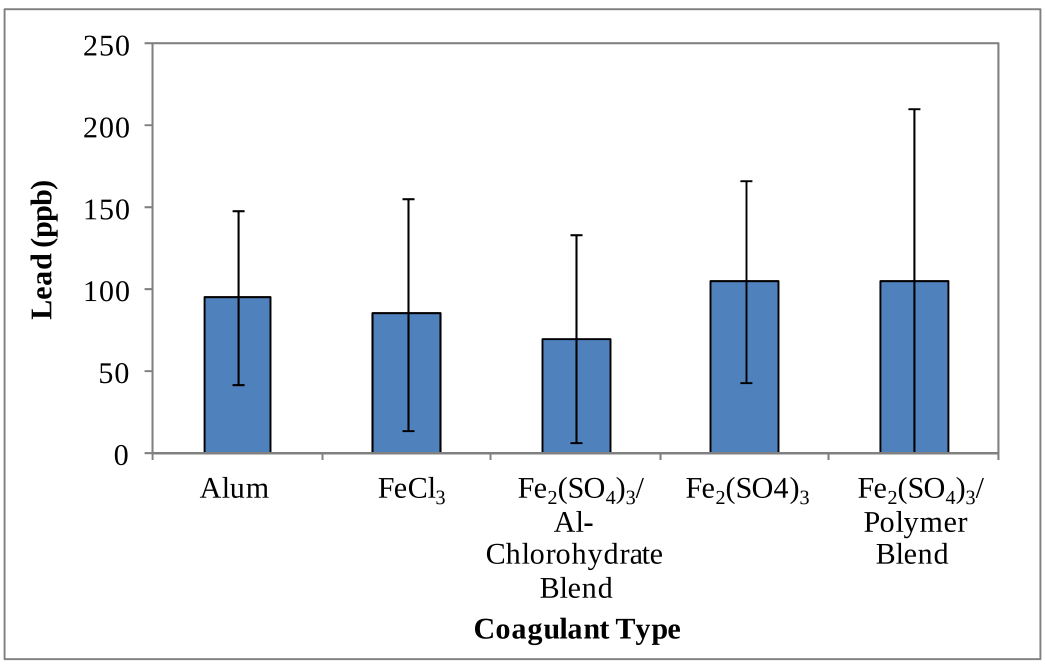


Figure 5.4 Lead leaching from brass for each of the simulated coagulation conditions for Utility G. The error bars depict the 95% confidence intervals.

blend). For example, water treated with the chlorohydrate blend coagulant was about 13 times more aggressive than the ferric sulfate-treated water and 5 times more aggressive than alum-treated water (Figure 5.5). Lead leaching from solder in this water is extraordinarily impacted by coagulation conditions, as manifested by changes in the CSMR.

If anything, the chlorohydrate blend actually caused more lead leaching than did the ferric chloride alone, although the difference was not significant at >95% confidence (Figure 5.5). This might be because this coagulant was not as effective at removing natural organic matter (1.9 vs. 1.3 mg/L as TOC). NOM is also known to increase lead leaching (Table 5.2). However, the TOC of the treated water did not correlate with the lead in the water when comparing all five coagulation conditions.

The ferric sulfate polymer blend is being considered due to the possibility of reducing caustic costs and the hypothesized ability to better control lead leaching with the addition of sulfate. However, the ferric sulfate polymer blend had 3 times higher lead than the current ferric sulfate coagulant and 50% more lead than alum. Therefore, the prospective ferric sulfate polymer blend is not recommended for future use as a coagulant.

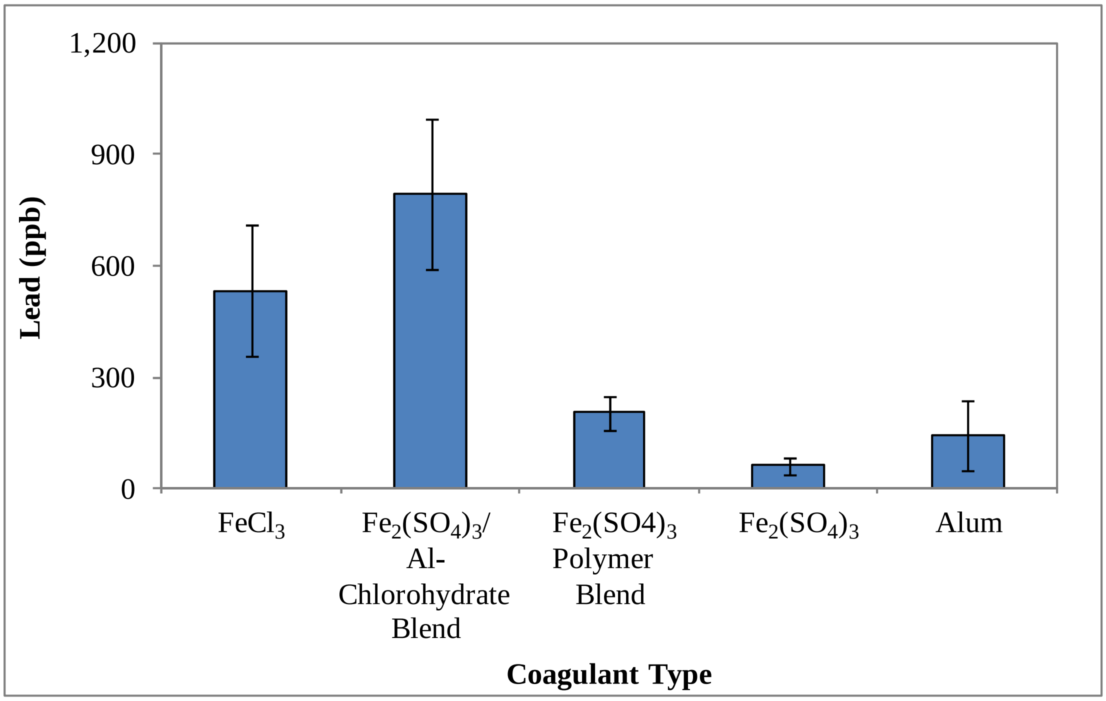


Figure 5.5 Lead leaching from galvanic solder for each of the simulated coagulation conditions for Utility G. The error bars show the 95% confidence intervals.

CONCLUSIONS

- Consistent with past experience, the condition that offered the best lead corrosion control was water treated with ferric sulfate.
- The chloride-based coagulants (ferric chloride and aluminum chlorohydrate blend) had the highest lead levels.
- The proposed ferric sulfate polymer blend did not exhibit promise in mitigating lead leaching, and its use cannot be recommended in the future for this utility.

CHAPTER 6
CASE STUDY OF UTILITIES B AND E, NC (COAGULANTS)

Caroline Nguyen, Kendall Stone, and Marc Edwards

Keywords: Coagulants, anion exchange, corrosion inhibitors, alkalinity, lime, ferric chloride, ferric sulfate, orthophosphate, silicate polyphosphate

INTRODUCTION

Bench scale experiments were undertaken for six weeks to study the effects of coagulant selection, corrosion inhibitor type and dose, alkalinity, and lime on lead leaching in water for two neighboring cities in North Carolina. Six different types of coagulation (including ferric sulfate and ferric chloride) and three corrosion inhibitors (including a silicate polyphosphate blend and orthophosphate) in treated waters were compared head-to-head in terms of lead leaching from brass (5% lead content), 50:50 Pb/Sn solder galvanically connected to copper, and pure lead pipe. These three lead materials are assumed to be present in the distribution systems throughout the city at some level of occurrence.

MATERIALS AND METHODS

Test Water

Utility E's raw water (Table 6.1) was shipped to Virginia Tech approximately every other week by the utility. Collected water was separated and subjected to simulated drinking water treatment, which was otherwise identical except for the type of coagulant or inhibitor used. Treatment involved coagulation, filtration, phosphate corrosion inhibitor addition (if specified), disinfection with chloramines, fluoride addition, and final pH adjustment. Utility E currently coagulates with ferric sulfate, doses a silicate polyphosphate blend corrosion inhibitor, and adjusts the final pH to around pH 8.0. Utility B coagulates with aluminum sulfate (alum), adds orthophosphate as a corrosion inhibitor, and adjusts the final pH to 7.6. A summary of the treatment scenarios and water quality information is provided in Table 6.2.

Table 6.1
Source Water Characteristics for Utility E

Parameter	Concentration
Sulfate	13 mg/L SO_4^{2-}
Chloride	9 mg/L Cl
Silicon	0.8 mg/L Si
Alkalinity	35 mg/L as $CaCO_3$

Coagulant Type

The six types of coagulation treatment evaluated were: (1) 100% ferric sulfate, (2) 100% ferric chloride, (3) blend of ferric chloride and ferric sulfate to achieve a CSMR of 0.3, (4) blend of ferric chloride and ferric sulfate to achieve a CSMR of 1.0, (5) anion exchange followed by a low dose of ferric sulfate, and (6) anion exchange followed by a low dose of ferric chloride. The ferric sulfate coagulant dose was provided by Utility E, and mixing speeds and times (rapid mix for one minute, 20 rpm for 20 minutes, and settling for 30 minutes) were selected to simulate to the extent possible the full-scale treatment practice in jar tests. The coagulant dose for the ferric chloride condition and the ferric chloride/sulfate blends were based on the total ferric dose (mg/L Fe^{3+}) that the treatment plant used. In the anion exchange conditions, the raw water was mixed for 1 hour with chloride-based anion exchange resin to remove natural organic matter (NOM) in the water, and the supernatant was collected and mixed with a third of the full ferric sulfate or ferric chloride dose.

Table 6.2
Summary of Test Conditions for Utilities B and E

Coagulant Type	Corrosion Inhibitor	Special Condition*	pH	CSMR
100% ferric sulfate	None	--	8.0	0.2
	Orthophosphate	--	7.6	0.2
	Silicate polyphosphate	--	8.0	0.2
		4X inhibitor dose	8.0	0.2
		Lime	8.0	0.2
		Higher alkalinity	8.0	0.2
100% ferric chloride	None	--	8.0	4.5
	Silicate polyphosphate	--	8.0	4.5
	Orthophosphate	--	7.6	4.5
Ferric blend – CSMR 0.3	None	--	8.0	0.3
	Silicate polyphosphate	--	8.0	0.3
	Orthophosphate	--	7.6	0.3
Ferric blend – CSMR 1.0	None	--	8.0	1.0
	Silicate polyphosphate	--	8.0	1.0
	Orthophosphate	--	7.6	1.0
Anion exchange, ferric sulfate	None	--	8.0	1.0
	Silicate polyphosphate	--	8.0	1.0
	Orthophosphate	--	7.6	1.0
Anion exchange, ferric chloride	None	--	8.0	5.9
	Silicate polyphosphate	--	8.0	5.9
	Orthophosphate	--	7.6	5.8

* if applicable

Corrosion Inhibitor and Target pH

Three corrosion inhibitors were evaluated for each of the six coagulation conditions: (1) no inhibitor at pH 8.0, (2) silicate polyphosphate blend at pH 8.0, and (3) orthophosphate at pH 7.6. The current dose of silicate polyphosphate used by Utility E and for this study was 0.74 mg/L SiO_2 and 0.28 mg/L phosphate. Additionally, the silicate polyphosphate inhibitor was tested at four times the current dose for ferric sulfate-treated water at pH 8.0. The no inhibitor condition and the silicate polyphosphate conditions were tested at Utility E's pH of 8.0. Utility B currently uses Orthophosphate for corrosion control; therefore, the target pH of 7.6 was selected to simulate the Utility B finished water. The dose of orthophosphate for this study was 1 mg/L as P. The pH was adjusted to the target value within 0.1 pH units with either 0.1 M NaOH or 0.1 M HNO_3 prior to exposure to the test coupons.

Alkalinity and Lime

The effects of higher alkalinity and lime were investigated for Utility E's current treatment with ferric sulfate coagulation and silicate polyphosphate corrosion inhibitor at and pH 8.0. A higher silicate polyphosphate level of four times the current inhibitor dose was also investigated for ferric sulfate-treated water. The higher alkalinity water was adjusted to 50 mg/L as $CaCO_3$ using sodium bicarbonate. Lime with 0.1% calcium hydroxide (CAL FLO slurry) was used in lieu of sodium hydroxide to increase the pH to 8.0.

Chloramines and Fluoride

The target chloramines disinfectant dose was 3.5 mg/L Cl_2, and the fluoride concentration was 0.9 mg/L F^-. The ratio of chlorine-to-ammonia for the chloramines was 4:1 mg Cl_2:mg N. Fluoride was added from hydrofluorosilicic acid.

Evaluated Lead Plumbing Materials

Three common lead bearing plumbing materials were evaluated for impacts on lead leaching. Brass, 50:50 Pb/Sn solder, and pure lead pipe were all exposed to water conditions listed in Table 6.2. Three replicates were tested for each condition to examine statistical confidence of key trends. Water exposed to the lead materials was changed twice per week (Monday and Thursday) and was otherwise stagnant. All materials were kept at room temperature throughout the testing period.

Solder

Simulated lead-copper joints were prepared using a 1-inch in length copper coupling (½-inch diameter copper) with a 1-inch length of 50:50 Pb/Sn solder melted inside (Figure 6.1). The solder-copper couplings were exposed to 100 mL of all water conditions listed in Table 6.2.

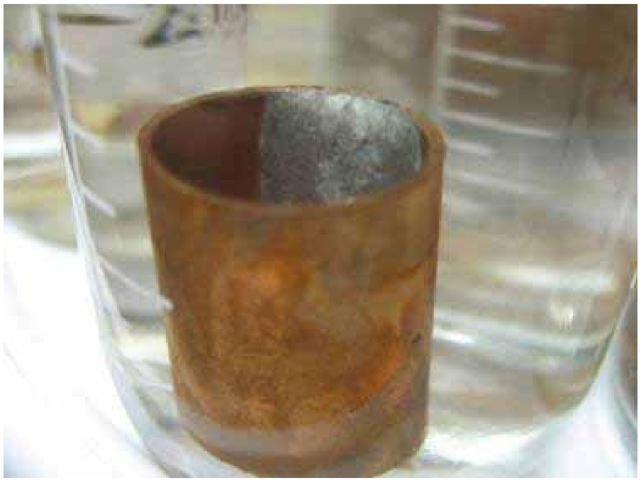


Figure 6.1 Solder-copper coupon used for Utilities B and E study.

Brass

Brass coupons (5% lead content) that were ½–inch in diameter were cut in 0.4-inch lengths and epoxied to the bottom of glass containers (Figure 6.2). The brass coupons were exposed to 50 mL of all water conditions listed in Table 6.2.

Lead pipe

New pure lead pipes, which were ½-inch in diameter and cut into 1-foot segments, were evaluated in this study (Figure 6.3). While one end of each pipe was sealed with a chemically inert silicone stopper, parafilm covered the other side to minimize abrasion of the lead material while emptying and filling the pipes during water changes. Only two water conditions were tested in lead pipes to evaluate the effects of lime for pH adjustment compared to caustic, which is currently by Utility E. Both evaluated waters were coagulated with 100% ferric sulfate and dosed with Utility E's current silicate polyphosphate dose.

Figure 6.2 Brass coupon (5% lead content) in glass container used in study for Utilities B and E.

Figure 6.3 New lead pipes used in the study for Utilities B and E.

Measurements

Composite weekly samples were routinely collected for each water condition (i.e., two water changes collected for each weekly sample) and lead material. The samples were acidified with 2% HNO_3 for at least 24 hours to dissolve metals. The unfiltered composite samples were analyzed for metals with Induced Coupled Plasma Mass Spectrometry (ICP-MS). At the end of the first six weeks, intensive sampling was conducted to establish statistical confidence intervals. In the intensive sampling event, water was collected for each test coupon after each water change for three consecutive water changes. Data in this report is from the period of intensive sampling.

RESULTS AND DISCUSSION

Effect of CSMR

Water with low CSMR (i.e., treated with 100% ferric sulfate or a blend to produce a CSMR of 0.3) consistently had lower lead leaching from solder and brass. The anion exchange treated waters and 100% ferric chloride coagulated water were among the highest in lead. Lead was shown to have a roughly positive correlation with CSMR (Figure 6.4).

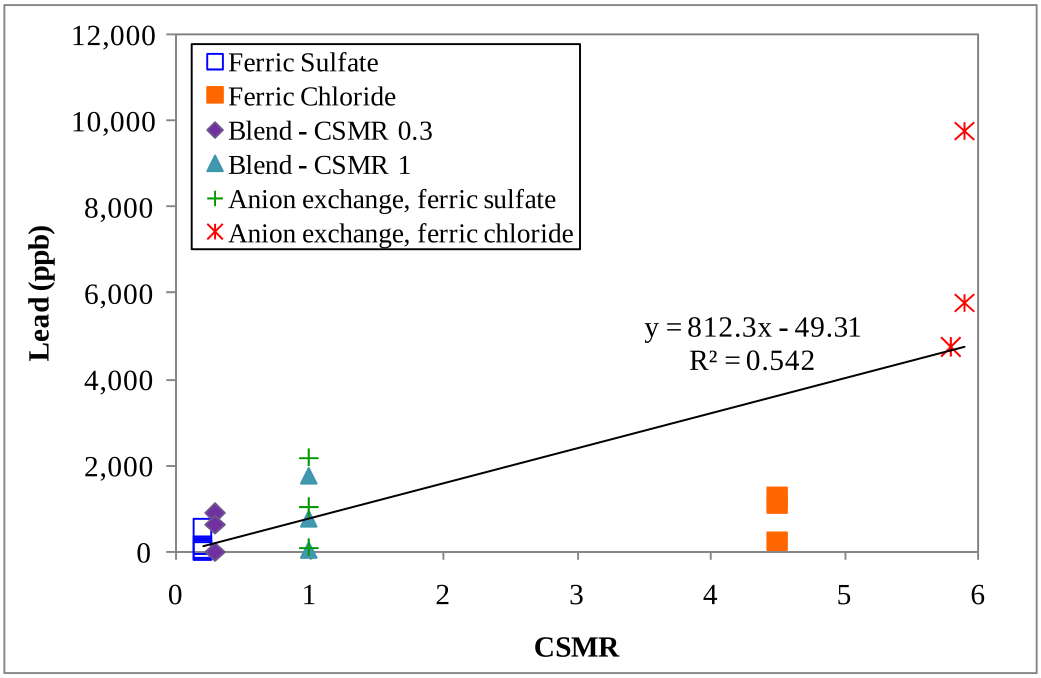


Figure 6.4 Lead leaching from solder as a function of the chloride-to-sulfate mass ratio (CSMR) for Utilities B and E.

Brass

The ranking of least to most aggressive water conditions in terms of lead leaching from brass was: (1) CSMR 0.3, (2) ferric sulfate, CSMR 1.0, and anion exchange with ferric sulfate, and (3) ferric chloride and anion exchange with ferric chloride (Figure 6.5). For example, the ferric chloride treated water had about 2.5 times more lead than the water treated with ferric sulfate. Water conditions that share a ranking level were shown to have no statistically significant difference based on t-tests.

Solder

The ranking of least to most aggressive water coagulation conditions in terms of lead leaching from 50:50 Pb/Sn solder galvanically connected to copper was: (1) ferric sulfate, (2) blend with final CSMR of 0.3, (3) blend with CSMR 1.0, ferric chloride, and anion exchange with ferric sulfate, and (4) anion exchange with ferric chloride (Figure 6.6). The ferric chloride treated water was about 6.5 times more aggressive than water coagulated with ferric sulfate for lead from solder. Lead leaching from solder in this water is extraordinarily impacted by coagulation conditions, as manifested by changes in the CSMR.

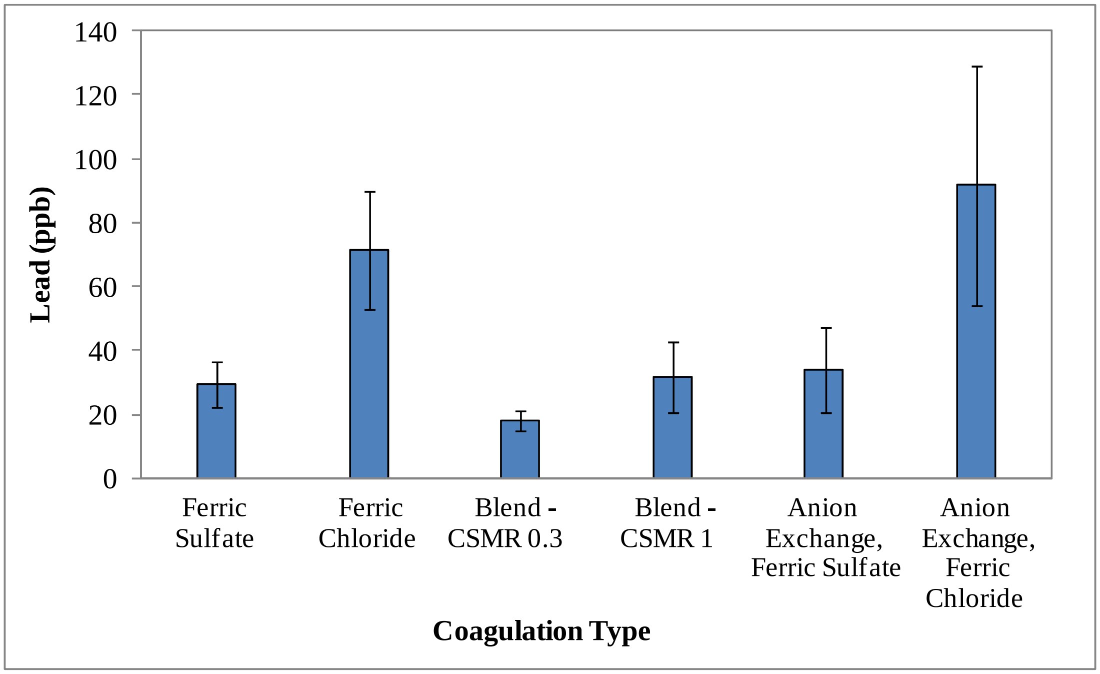


Figure 6.5 Lead leaching from brass for each of the simulated coagulation conditions for Utilities B and E. The error bars depict the 95% confidence intervals.

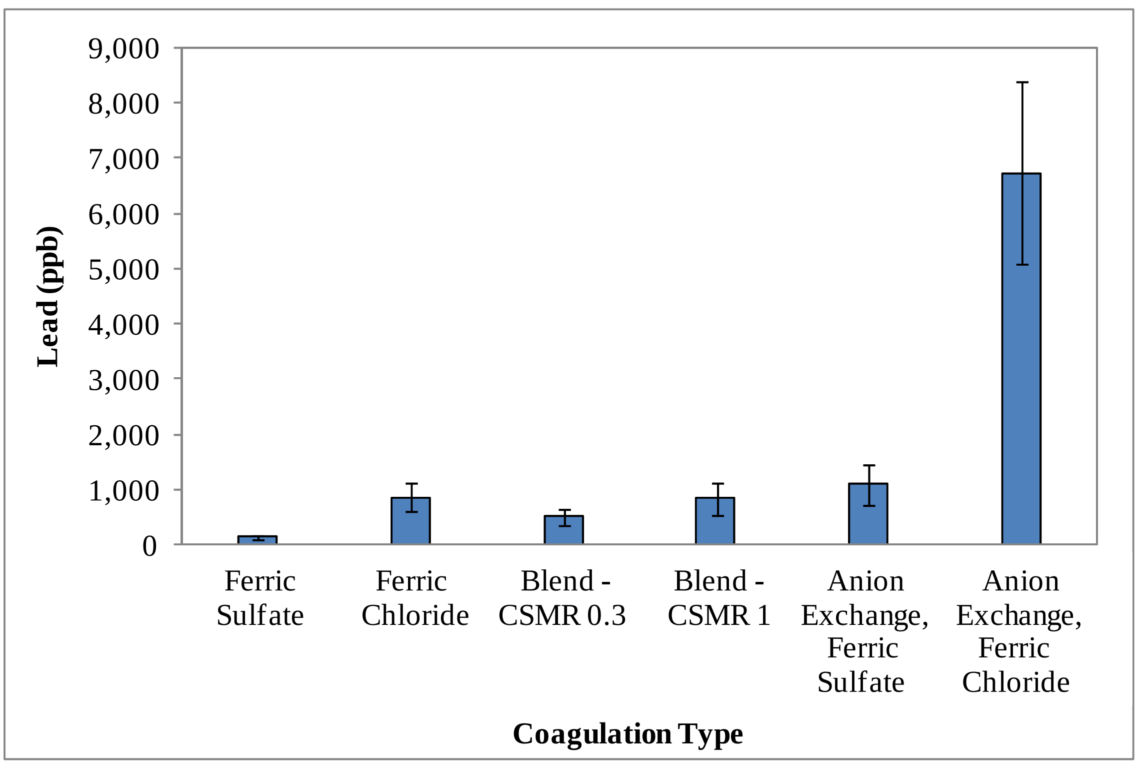


Figure 6.6 Lead leaching from galvanic solder for each of the simulated coagulation conditions for Utilities B and E. The error bars show the 95% confidence intervals.

Effect of Corrosion Inhibitors

Brass

Orthophosphate was the most effective corrosion control of lead from brass (p-value < 0.04). Adding no inhibitor to the water resulted in approximately 4 times more lead than did orthophosphate, and 2 times more lead than silicate polyphosphate (Figure 6.7).

Solder

Orthophosphate dramatically decreased lead from solder when excluding the condition with anion exchange followed by ferric chloride coagulation. Other studies performed at Virginia Tech also found that orthophosphate can actually increase the lead leaching in waters with high amounts of chloride. For this study, dosing orthophosphate almost doubled the amount of lead measured in water for the highest CSMR condition (anion exchange followed by ferric chloride coagulation; resulting CSMR of 5.9). Excluding the highest CSMR condition, water with no inhibitor had 1.7 times more lead than water with Utility E's current dose of silicate polyphosphate (Figure 6.8). Furthermore, the condition with no inhibitor or the condition of silicate polyphosphate inhibitor had about 20 times and 12 times more lead, respectively, than water with orthophosphate.

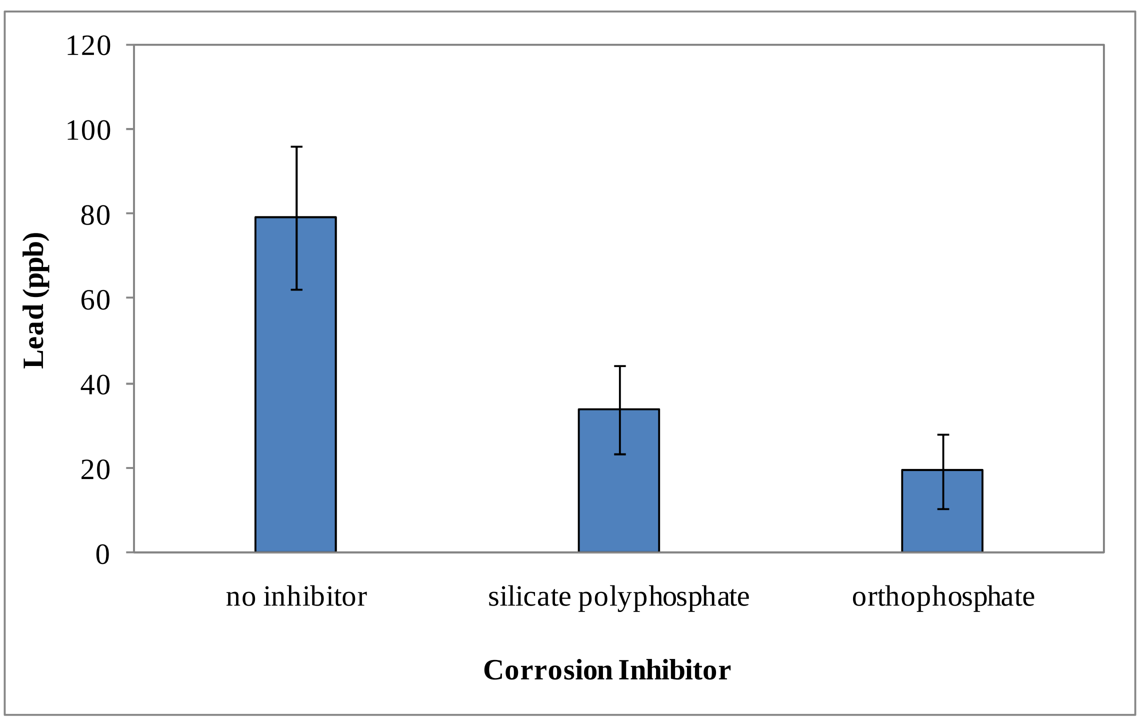


Figure 6.7 Effect of corrosion inhibitors on lead leaching from brass for Utilities B and E. The error bars show the 95% confidence intervals.

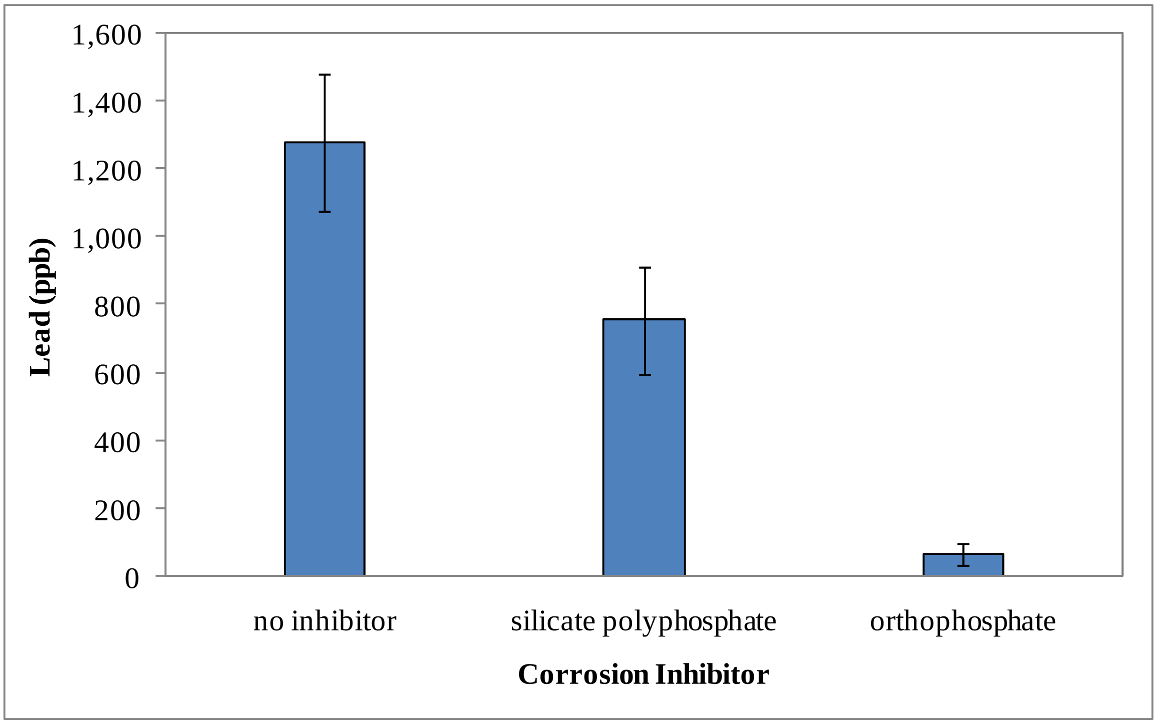


Figure 6.8 Effect of corrosion inhibitors on lead leaching from solder for Utilities B and E. The error bars show the 95% confidence intervals.

Effect of Lime

The use of lime instead of caustic to increase pH resulted in no difference in lead leaching for solder:copper galvanic connections, lead pipe, and brass. Although lead leaching from brass initially increased by about 3.7 times from 15±2 ppb to 54±32 ppb with the use of lime (Figure 6.9), further testing for the utility suggested that brass is actually not affected by lime.

Lead Corrosion in Water Coagulated with Ferric Sulfate

Brass

Orthophosphate, a typical dose of silicate polyphosphate, and higher alkalinity of 50 mg/L as $CaCO_3$ produced the lowest levels of lead from brass (Figure 6.10). The worst conditions were water with no inhibitor, lime with silicate polyphosphate, and quadruple the current silicate polyphosphate dose. Approximately three times more lead was released from the more aggressive conditions than the less aggressive conditions.

Solder

The ranking from best to worst lead leaching for solder exposure was: (1) orthophosphate, (2) higher alkalinity, (3) 4 X silicate polyphosphate dose, (4) lime with silicate polyphosphate, (5) current dose of silicate polyphosphate, and (6) no inhibitor. Adding orthophosphate resulted in a 98% decrease in lead compared to when no inhibitor was added

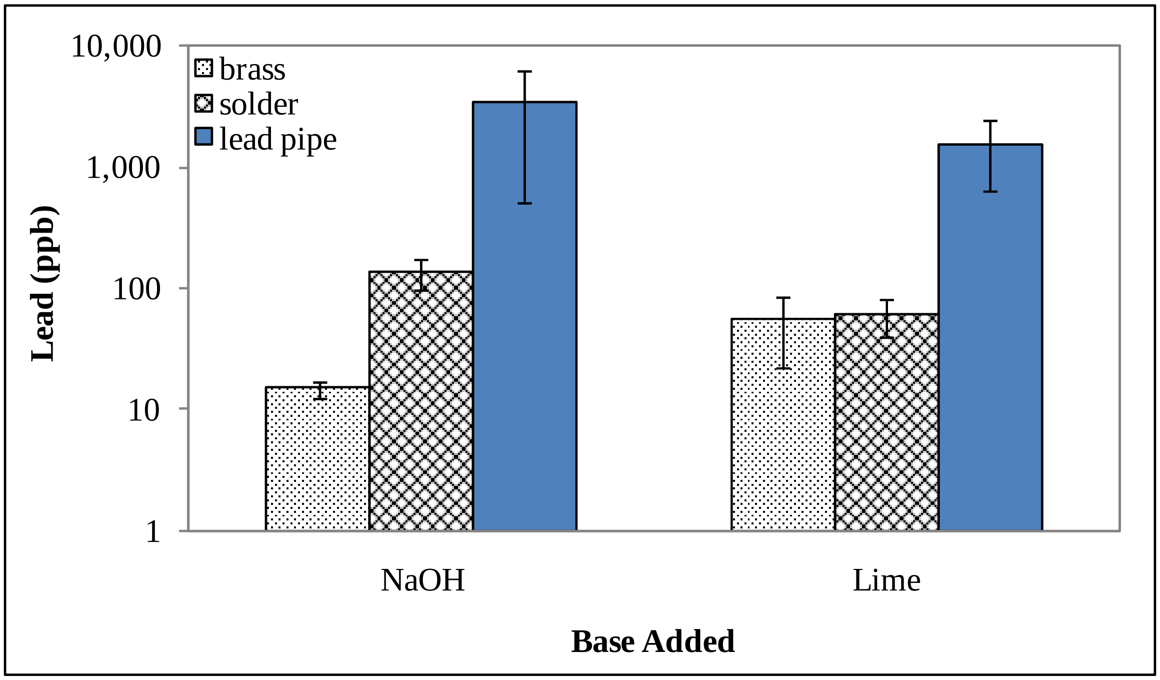


Figure 6.9. Comparison of lime and caustic for pH adjustment. The error bars show the 95% confidence intervals.

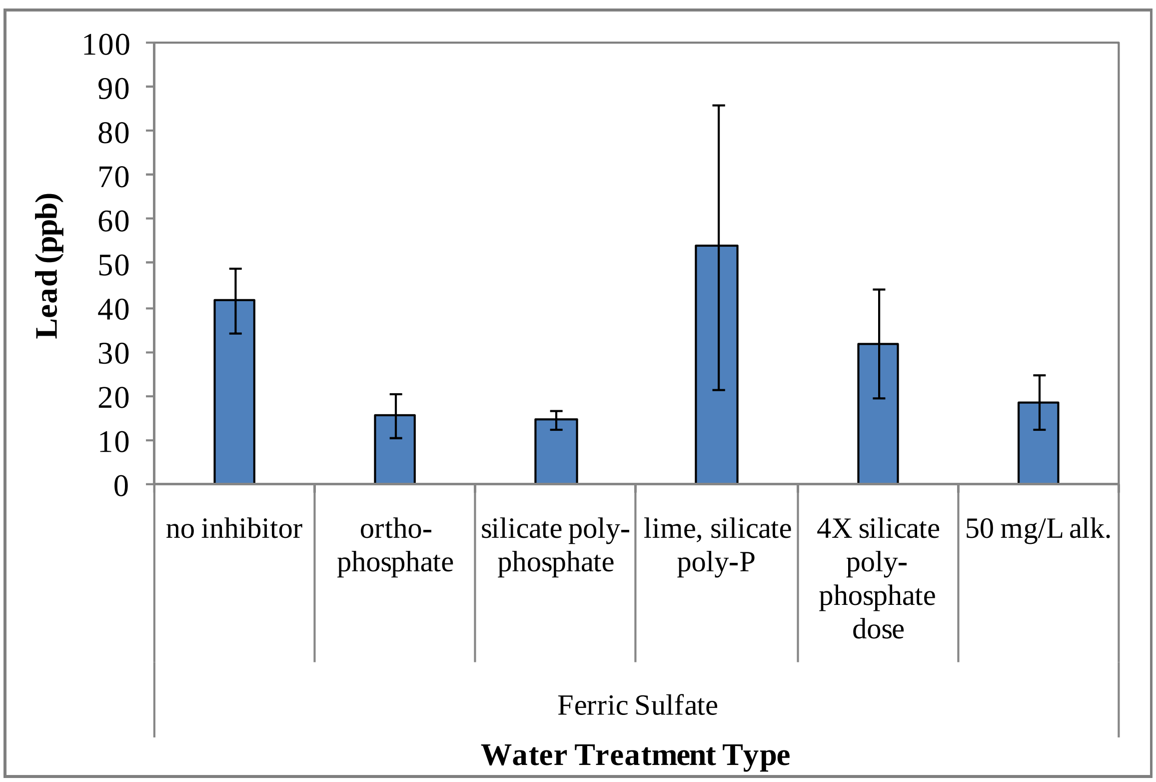


Figure 6.10 Lead from brass for water coagulated with 100% ferric sulfate. The error bars show the 95% confidence intervals.

(Figure 6.11). Although the increase in silicate polyphosphate dose resulted in a proportional decrease in lead leaching to water, the lead leaching did not decrease to the levels of orthophosphate. By increasing the alkalinity in water coagulated with ferric sulfate, lead leaching from solder was reduced compared to when silicate polyphosphate was added alone; however, the reduction was not to the same extent as reduction due to orthophosphate.

CONCLUSIONS

- The condition that offered the best lead corrosion control was water coagulated with ferric sulfate and dosed with 1 mg/L PO_4-P.
- Anion exchange using a chloride-based resin increases chloride in drinking water.
- Lead leaching from solder-copper couples increased with higher CSMR.
- Orthophosphate was effective in reducing lead leaching from brass and solder-copper coupons. However, orthophosphate dosed in the highest CSMR condition (CSMR of 5.8) doubled the amount of lead released to the water.
- Lime, which has become a more economical alternative to caustic for many utilities, did not appear to impact the levels of lead.

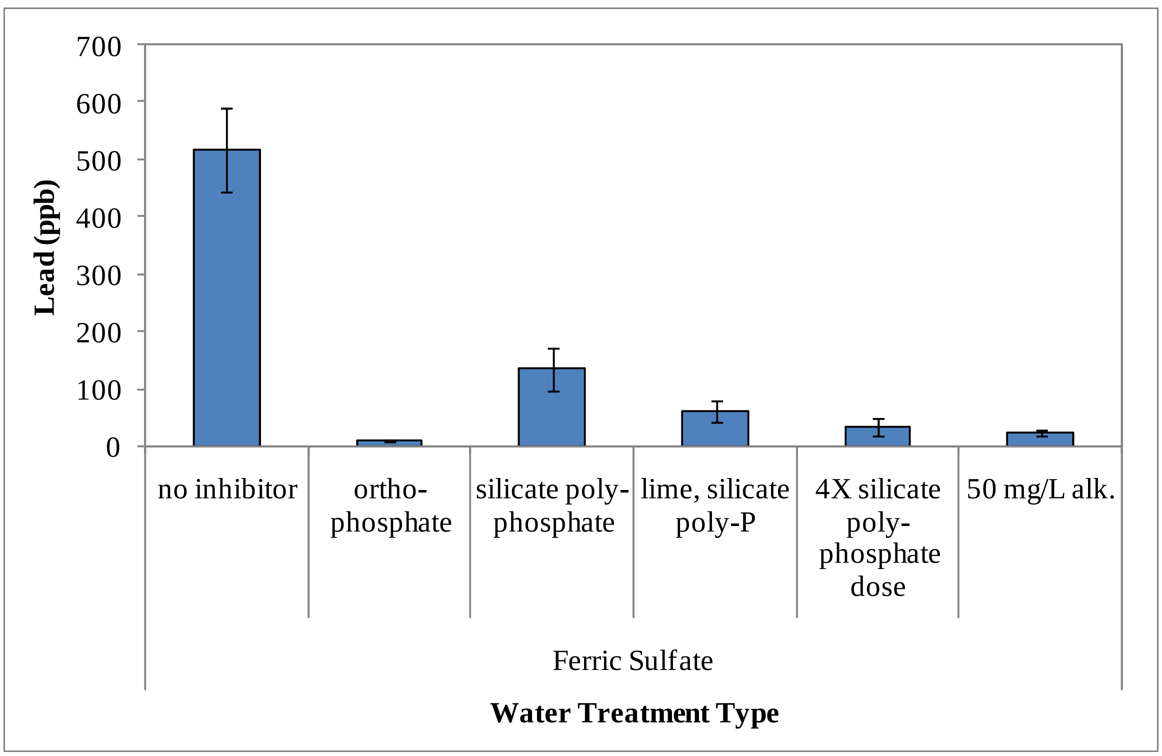


Figure 6.11 Lead from solder for water coagulated with 100% ferric sulfate. The error bars show the 95% confidence intervals.

CHAPTER 7
CASE STUDY OF UTILITY D, NOVA SCOTIA (COAGULANTS)

Alisha Knowles and Graham Gagnon

Keywords: Coagulants, alum, ferric sulfate, polyaluminum chloride, polyphosphate

INTRODUCTION

Utility D in Nova Scotia has collaborated with Dalhousie University to execute a long-term water quality research program to ensure safe, high quality water is delivered to its consumers through the development of effective treatment solutions for their facilities. As part of this research program, Dalhousie University is currently investigating coagulation and flocculation processes at the utility to optimize NOM removal to mitigate the formation of disinfection by-products (DBPs). This includes the evaluation of alternative coagulants to achieve such goals and, subsequently, the evaluation of potential "unintended consequences" of such chemical changeovers on finished water quality and distribution systems with respect to metal release occurrences. It is essential that the research results achieve a balance between coagulation optimization techniques to meet pending treatment objectives and the role of lead leaching associated with each.

The Utility D treatment plant is a direct filtration plant that treats surface water characterized by low alkalinity, turbidity, and organic matter. In general, the data relating CSMR and lead leaching in systems with water sources characterized by low alkalinity and turbidity is limited and more research is required to validate the effects of CSMR. Coagulant changeover cases suggest that a high chloride (Cl^-) to sulfate (SO_4^{2-}) mass ratio (CSMR) governs lead leaching incidences in distribution systems (Dodrill and Edwards 1995; Dudi 2004; Edwards and Triantafyllidou 2007). When chloride and sulfate co-exist in a distribution system, the concentration of sulfate must be sufficient to overcome the counteractive effects of chloride (Edwards and Triantafyllidou 2007). Common coagulants are typically chloride and sulfate based (i.e.; aluminum sulfate, ferric chloride, polyaluminum chloride, ferric sulfate, etc), therefore, changes in the coagulant at water treatment plant can significantly alter the ratio of chloride and sulfate concentrations in the finished water. The critical CSMR level cited from multiple bench scale and full-scale studies that governs the effects of lead leaching is 0.5 mg of chloride per mg of sulfate (Dodrill and Edwards 1995; Dudi, 2004; Edwards and Triantafyllidou 2007). Above this level, galvanic corrosion of lead pipe is increased, and below this threshold, lead leaching is mitigated.

Bench scale experiments were conducted to evaluate the effects of coagulant changeovers and the CSMR changes induced by such changeovers on both lead and copper leaching in the distribution system. The coagulants evaluated include aluminum sulfate (alum), ferric sulfate, and polyaluminum chloride (PACl). The two lead bearing plumbing materials studied were lead:tin solder and harvested lead pipe, both in connection with copper pipe.

MATERIALS AND METHODS

The experimental design and procedure was based on lead leaching studies in plumbing materials resulting from coagulant changeovers being lead by Edwards and co-workers (e.g., Nguyen et al. 2008).

Apparatus

Bench scale pipe set-ups were designed to compare the leaching effects of lead:tin solder and harvested lead pipe, both in connection with copper pipe through two pipe set-ups:

Pipe Set-up 1

- Pb pipe – Pb/Sn solder – Cu pipe
- extracted lead pipe with a pre-existing pipe scale connected to copper using a simulated 40:60 lead:tin solder joint

Pipe Set-up 2

- Cu pipe – Pb/Sn solder – Cu pipe
- copper to copper pipe connection using a simulated 40:60 lead:tin solder joint

Pipe Set-up 1 was composed of a 12.25” length of extracted ¾” lead pipe connected to a 2.5” length of ½” copper pipe using clear tubing and leaving an approximately 2-mm gap between the two pipes (Figure 7.1). The pipe sizes and experimental set-up were chosen to induce the worst-case scenario with respect to high corrosion and lead leaching conditions and to allow for micro-electrode measurements within the pipes (Nguyen et al. 2008). To simulate a soldered joint, solder wire was inserted through the ½” copper pipe until it reached the interface of the two pipes (Figures 7.1 and 7.2). The solder and pipes were electrically connected using copper wires and clips to simulate a galvanic connection. The pipes were capped using silicone stoppers throughout the experiment. Pipe Set-up 2 was erected in the same manner, except the simulated solder joint was connected to two copper pipes.

Test Water

The test water was treated to simulate, within reason, all conditions in the current full-scale treatment process (i.e.; chemical dosages, detention times, mixing regimes, etc.). All water conditions were subjected to identical treatment processes, with the only differences being the coagulant type, dosage and coagulation pH used. The coagulants evaluated included alum, ferric sulfate and PACl. Coagulant dosages were calculated as an equivalent metal molar ratio based on the 8 mg/L alum dosage currently employed in the full-scale treatment plant. Optimal coagulation pHs were determine through jar testing for each coagulant used.

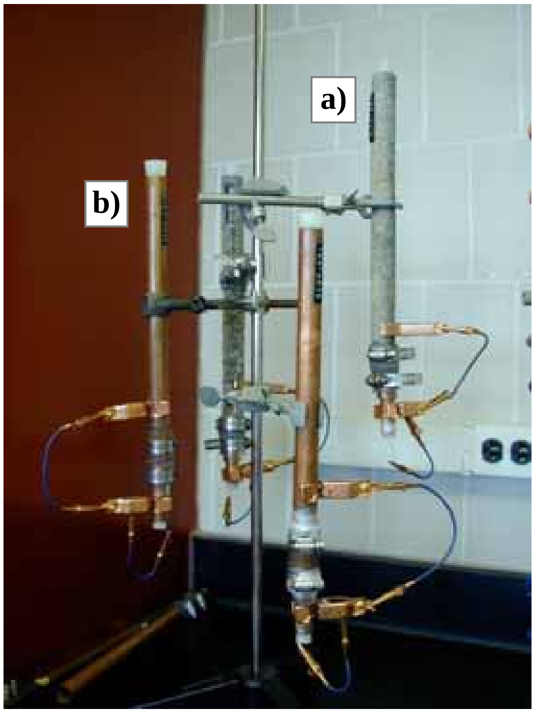


Figure 7.1 Picture of 4 of 12 pipe setups: a) Pb pipe – Pb/Sn solder – Cu pipe; b) Cu pipe – Pb/Sn solder – Cu pipe

Figure 7.2 Picture of simulated 40:60 Pb/Sn soldered joint for Utility D.

Pre-oxidized water was drawn from the full-scale plant and was subsequently coagulated, filtered through a 1.5 µm filter paper, and dosed with the following chemicals for final treatment: 1) polyphosphate corrosion inhibitor/iron and manganese sequestering agent addition of 1.65 mg/L (0.5 mg/L as phosphate), 2) disinfectant addition of 1.3 mg/L chlorine, and 3) final pH adjustment using sodium hydroxide to 7.4. Treated water for each condition was made in batches as required but was only treated as far as the direct filtration stage. The finished water chemicals were added immediately before the water change occurred. Since this study involved changing the coagulant type, dosage, and coagulation pH, the finished water alkalinity and organic content were different between the three water conditions. Table 7.1 presents the raw water and treated water quality characteristics for each water condition tested. Clearly, the condition with the ferric sulfate is an outlier relative to coagulant performance, since it had twice the alkalinity and more TOC relative to the other coagulant conditions.

Based on the hypothesis that the CSMR is the controlling factor with respect to lead release, it is theorized that the ferric sulfate (CSMR of 0.91) and alum (CSMR of 0.93) water conditions would have similar levels of lead leaching, since their CSMR levels are approximately the same. The PACl (CSMR of 2.1) treated water was expected to correlate with a higher lead release, since the CSMR is more than double that of the other two treated water conditions. However, because the CSMRs of the waters were relatively high (>0.58), other factors such as TOC and alkalinity may have a larger role in lead release.

Protocol

For the testing, the two pipe set-ups were exposed to the 3 water conditions. Each test was performed in duplicate; therefore, 12 tests were conducted in total. Exposure of the finished water to each pipe condition was via a static "dump-and-fill" protocol three times per week. The water changes occurred on Monday (M), Wednesday (W) and Friday (F), therefore yielding two stagnation periods of 48 hours (M-W, W-F) and one stagnation time of 72 hours (F-M). Over

Table 7.1
Average water characteristics for raw and treated water conditions for Utility D. The error values indicate the 95% confidence interval.

Parameter	Raw Water	PACl	Alum	Ferric Sulfate
Coagulant Dosage (mg/L)	---	1.5	8.0	5.4
Coagulation pH[1]	---	6.0	5.5	5.0
Alkalinity (mg/L as $CaCO_3$)	0	16.3 ± 1.6	16.8 ± 2.8	32.6 ± 7.4
TOC (mg/L)	2.89 ± 0.13	1.86 ± 0.57	1.88 ± 0.10	2.50 ± 0.20
DOC (mg/L)	2.82 ± 0.13	1.86 ± 0.55	1.81 ± 0.24	2.13 ± 0.41
CSMR	1.49	2.06 ± 0.25	0.93 ± 0.10	0.91 ± 0.10

[1]Finished water pH is 7.4.

the 27-week duration of the experiment, the samples obtained after each water change were tested for total metals content (lead, copper, and tin) using an atomic absorption graphite furnace (PerkinElmer Analyst 200), and an anion analysis was performed using ion chromatography to monitor chloride, sulfate, and phosphate levels. After week 17, samples were filtered through 0.45 µm pore size filters and analyzed for dissolved metals. The TOC, UV254, turbidity, pH, and alkalinity of each batch of treated water were monitored.

Measurements of chloride and pH were attempted at the lead and copper material surface using micro-probe technologies to track further mechanisms of corrosive attack. However, the measurements had a negative effect on the experimental results, and these effects are described in the results section.

RESULTS AND DISCUSSION

For all water conditions, the total lead entering the pipe set-ups was not detectable. Figures 7.3 and 7.5 present the total lead released from each of the pipe-set-ups throughout the 27 weeks of this study. Figures 7.4 and 7.6 present the dissolved lead released from each of the pipe-set-ups from weeks 17 to 27 of this study. The conditioning or acclimation period for both pipe-set-ups was between 5 and 6 weeks.

The total lead spikes observed throughout the first 6 weeks for the extracted lead pipes (Figure 7.3) can be attributed to lead particles sloughing off the extracted pipe during this initial acclimation phase and sitting at the bottom of the pipe set-up during stagnation and causing increased lead concentrations in the sampled water. Additionally, lead spikes were observed in both pipe-setups in Week 11 following micro-electrode measurements (Figure 7.3 and 7.5). In order to gain more insight into the localized effects at the solder surface and pipe interface, chloride and pH micro-electrodes were placed inside the test pipes before the water was changed at the end of Week 10, which disturbed the surfaces within the pipes and increased lead levels the following week. These lead spikes were caused by the electrodes scraping the lead pipe walls and disturbing the lead:tin solder. The increased lead release effects were significantly worse in the extracted lead pipe set-up, due to additional lead particles sloughing off the mature pipe scale inside of the pipe. Thus, no further microelectrode measurements were collected for the remainder of the study. Following this disturbance, the lead release data returned after one or two weeks to the apparent trends that was surfacing prior to the use of the microelectrodes .

Generally, lead leaching was very high in this study, which was expected since all of the CSMR values exceeded the threshold value of 0.5 for all water conditions tested (Edwards and Triantafyllidou 2007). Additionally, the geometry and physical experimental set-up were designed to maximize the worst-case conditions that contribute to lead corrosion (Nguyen et al. 2008). However, there was significantly more lead leached due to the presence of the combination of extracted lead and lead:tin solder, as opposed to the presence of lead:tin solder alone. Additionally, the polyphosphate inhibitor did not protect the lead bearing materials from corrosion.

It was expected that the ferric sulfate and alum water conditions would lead to similar levels of lead leaching, since their CSMR levels were approximately the same, and that the PACl treated water would correlate with a higher lead release, since the CSMR levels were more than double that of the other two water conditions. The trends reported from this study did not support this hypothesis. However, the results are consistent with other findings in the project in that other factors are important when the CSMR is greater than 0.5. Unlike the other case studies

in this Water Research Foundation project, the coagulation pH, TOC, and alkalinity were different among the water conditions. Therefore, TOC and alkalinity could affect the lead leaching to a greater extent than the CSMR.

Pipe Set-up 1: Pb pipe – Pb/Sn solder – Cu pipe

The ferric sulfate water was the most corrosive condition for the extracted lead pipe set-up, whereas, the alum and PACl treated waters behaved similarly despite the large CSMR differences between the two water conditions (Figures 7.3). For all conditions, the lead levels continued to decrease over time; however, more dramatic decreases were observed for the alum and PACl conditions, particularly in the first half of this study. The dissolved lead trends observed throughout the last 10 weeks of the study were significantly less than the total lead concentrations; however, similar trends were observed with respect to CSMR (Figure 7.4). This indicates that the majority of the lead released was in a particulate form. The high levels of particulate lead could be attributed to plumbing scales being broken down on the extracted lead pipe despite the corrosion inhibitor presence. For this reason, the dissolved lead trends were much less variable than total lead trends. The peak observed in weeks 24 through 25 for the alum water condition was likely a result of the lead solder being exposed to the atmosphere for maintenance of the simulate solder connection (Figure 7.3). A small portion of the solder was replaced with new material to repair the solder joint.

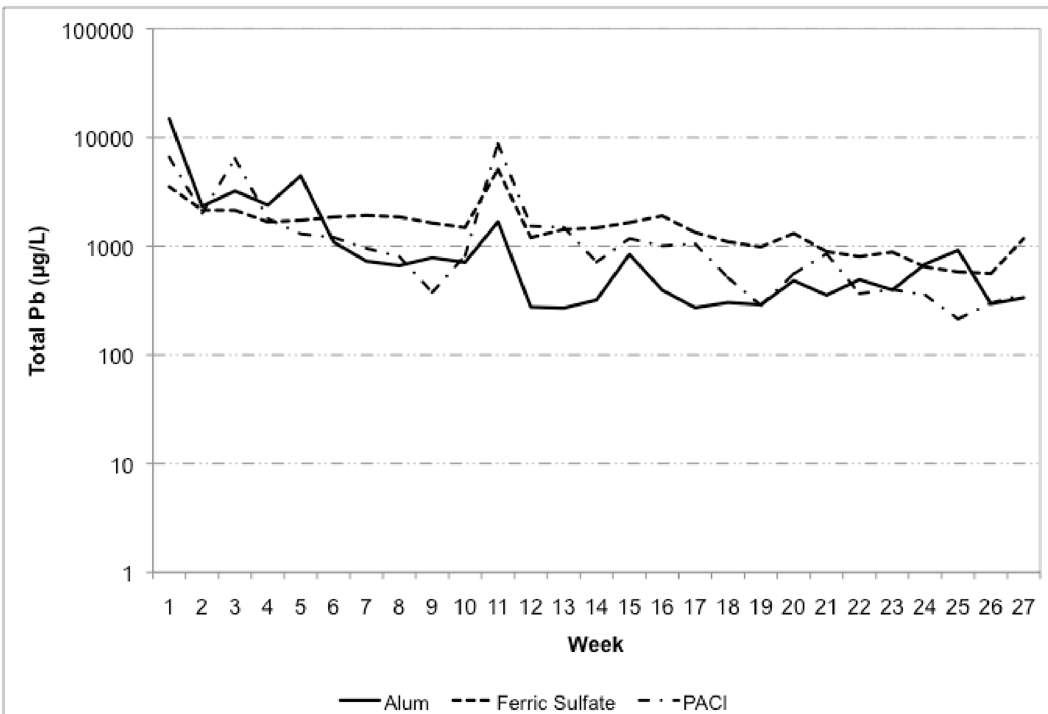


Figure 7.3 Total lead concentrations throughout the 27 weeks of the study for the Pb pipe – Pb/Sn solder – Cu pipe scenario. Data from the three samples per week and duplicate pipes were averaged to obtain the comparisons in this figure.

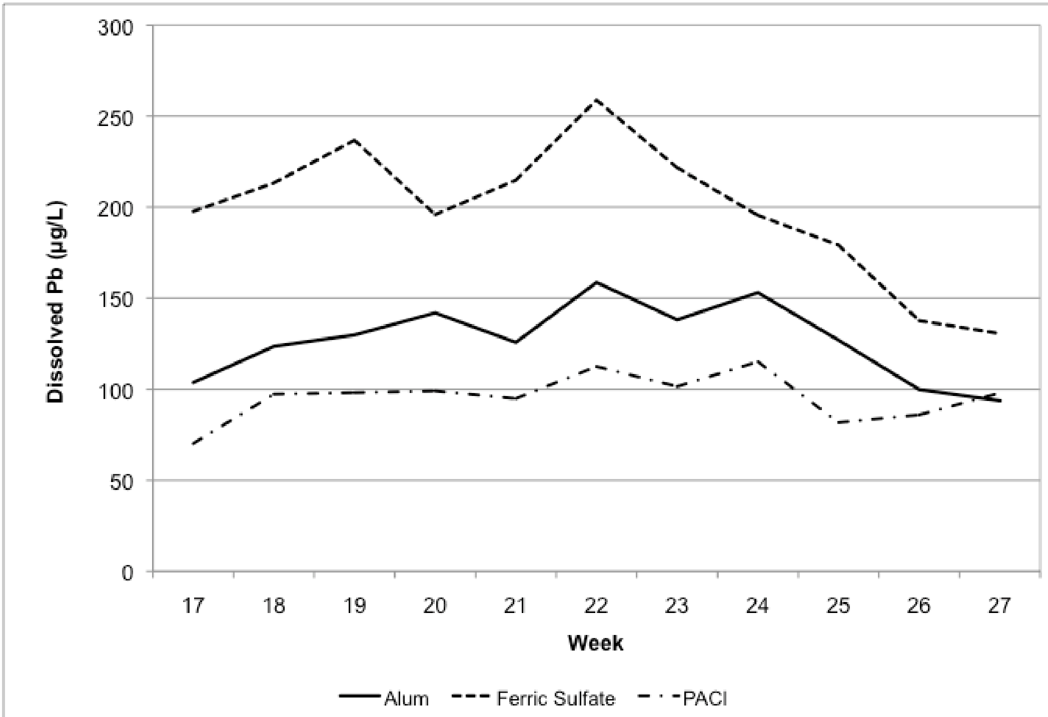


Figure 7.4 Dissolved lead concentrations throughout Weeks 17 to 27 of the study for the Pb pipe – Pb/Sn solder – Cu pipe scenario. Data from the three samples per week and duplicate pipes were averaged to obtain the comparisons in this figure.

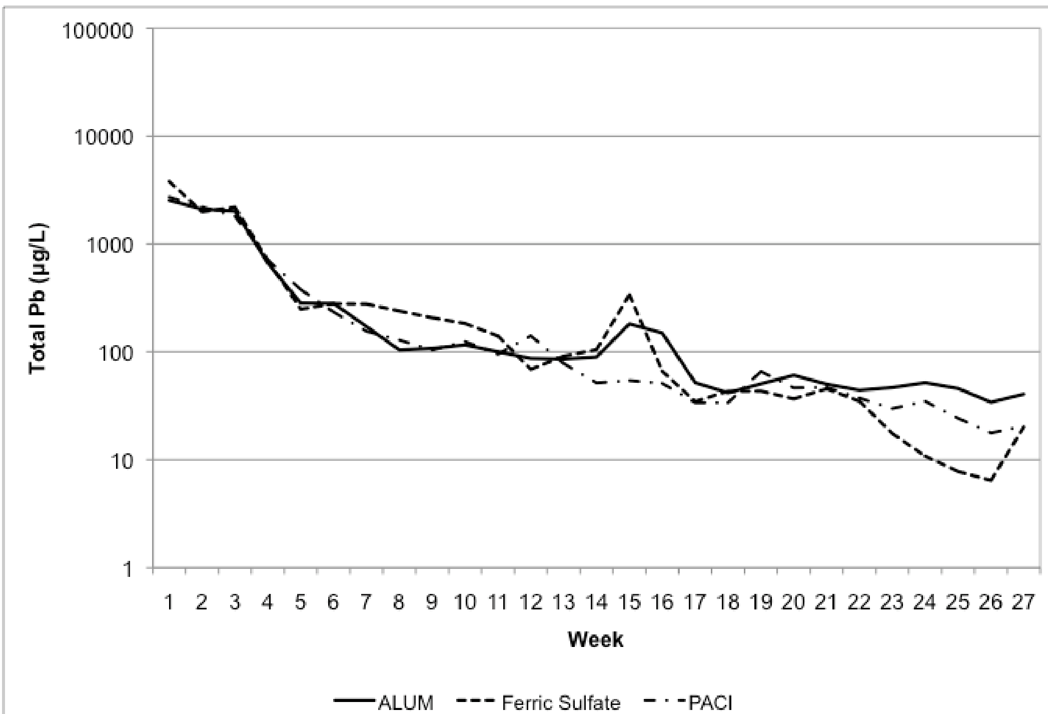


Figure 7.5 Total lead concentrations throughout the 27 weeks of the study for the Cu pipe – Pb/Sn solder – Cu pipe scenario. Data from the three samples per week and duplicate pipes were averaged to obtain the comparisons in this figure.

Pipe Set-up 2: Cu pipe – Pb/Sn solder – Cu pipe

Over the duration of the study, the considerable variability in total lead release was such that no considerable difference could be seen among the water conditions for the pipe set-up containing lead:tin solder as the only lead bearing material (Figure 7.5). For all conditions, the lead levels continued to decrease over time. However, much more dramatic decreases were observed for the solder only pipe scenario in comparison to the extracted lead pipe condition. The dissolved lead concentrations observed throughout the last 10 weeks of the study were significantly less than the total lead concentrations, indicating that a majority of the lead being release was in a particulate form (Figure 7.6). However, the amount of particulate lead being released was much less than that released from the extracted lead pipe condition. As was true for the extracted lead condition, the dissolved lead trends were less variable than the total lead trends. Additionally, the total lead variability was less apparent in the solder only condition than the extracted lead pipe condition. Over a longer study duration (and perhaps if the pipes had not been disturbed in week 10), it is possible that all water conditions could have much lower total and dissolved lead levels for this pipe condition.

Direct comparisons of the average total lead release in both plumbing scenarios for Weeks 14 through 27 of this study are presented in Figure 7.7 and Table 7.2. For the extracted lead pipe scenario, the ferric sulfate condition released an average of approximately 1.5 to 2.5 times more lead than the PACl and alum conditions. The differences in average total lead concentrations for the alum and PACl conditions for the extracted lead pipe scenario was not considered significantly different, and the 90% confidence intervals of the water conditions overlapped.

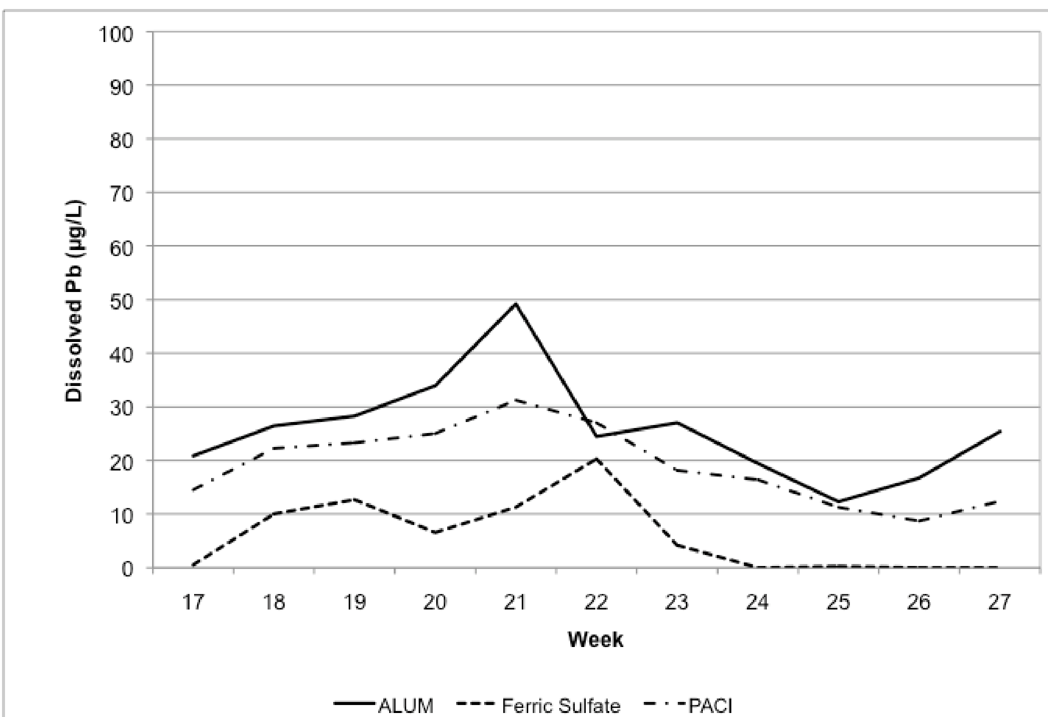


Figure 7.6 Dissolved lead concentrations throughout Weeks 17 to 27 of the study for the Pb pipe – Pb/Sn solder – Cu pipe scenario. Data from the three samples per week and duplicate pipes were averaged to obtain the comparisons in this figure.

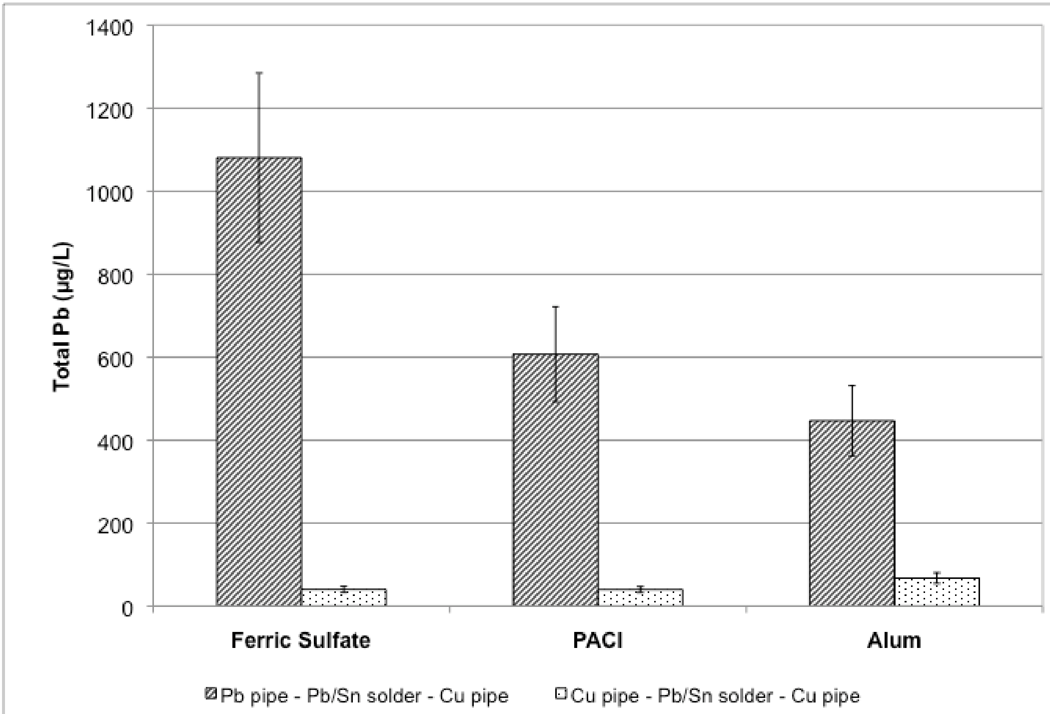


Figure 7.7 Average lead release data for each water condition during Weeks 14 through 27 of the Utility D study. Data from the three samples per week and duplicate pipes were averaged to obtain the comparisons. The error bars indicate the 90% confidence interval.

Table 7.2
Average lead release for each water condition during Weeks 14 through 27 of the Utility D study (±90% confidence interval). Data from the three samples per week and duplicate pipes were averaged to obtain the comparisons in this figure.

Water Condition	Lead (µg/L)	
	Pb pipe Pb/Sn Solder Cu pipe	Cu pipe Pb/Sn Solder Cu pipe
Ferric Sulfate	1080 ± 204	40 ± 8
PACl	607 ± 114	40 ± 8
Alum	447 ± 84	68 ± 13

Despite the CSMR differences, there was no considerable difference in average lead concentrations between each water condition for the solder only pipe scenario; however, the lead released from the alum condition was slightly higher and significantly different at the 90% confidence interval. On average, the extracted lead pipe condition resulted in lead concentrations 6.5 times more than the lead/tin solder to copper condition for alum, 15 times

more for PACl and 27 times for the ferric sulfate treated water. The lead release was expected to be higher in the extracted lead pipes because there were two sources of lead (lead pipe and solder) in the apparatus versus one source for the second pipe setup (solder).

CONCLUSIONS

- The extracted lead pipes connected to lead:tin solder and copper pipes maintained significantly higher lead concentrations for each water condition compared to when lead:tin solder was the only source of lead. This is consistent with expectations given that there were multiple lead materials in the lead pipe apparatus.
- Ferric sulfate released the most lead for the extracted lead pipe scenario, whereas the PACl and alum lead trends were not significantly different from each other.
- The lead release from the scenarios where solder was the only lead source was not significantly different for the three water conditions tested.
- All of the water conditions had CSMRs greater than the threshold of 0.5. Consistent with other findings when the CSMR of the raw water was high, no definitive trends were observed relating CSMR to lead leaching concentrations:
    - The highest CSMR condition (PACl with a CSMR of 2) did not yield the highest lead concentrations.
    - The replicate CSMR conditions (alum and ferric sulfate with CSMRs of 0.9) did not yield similar lead levels.
- CSMR was not the only factor contributing to lead release:
    - Alkalinity and TOC appear to be the other contributing factors (Table 7.1).
    - Lead release trends associated with alkalinity changes have been observed in data from other participating utilities.
    - There is evidence that NOM has adverse effects on lead release (Korshin et al. 2005).

CHAPTER 8
CASE STUDY OF UTILITY K, CA (DESALINATION)

Kendall Stone, Caroline Nguyen, and Marc Edwards

Keywords: desalination, nanofiltration

INTRODUCTION

Utility K plans to blend desalinated water with treated groundwater, which among other impacts will increase the chloride-to-sulfate mass ratio (CSMR) of the water. Prior research has indicated that this can cause serious lead leaching problems from lead solder:copper joints and brass under at least some circumstances. Virginia Tech examined the effects of a range of desalinated water and groundwater blends on the corrosion of lead-bearing plumbing materials including solder and brass. Six water conditions were evaluated through bench scale tests to determine the effects of blending desalinated water.

MATERIALS AND METHODS

Test Water

Utility K shipped samples of groundwater and nanofilter-treated water to Virginia Tech. The alkalinity of the nanofiltered water was adjusted to 40 mg/L as $CaCO_3$ by adding $NaHCO_3$ prior to blending with groundwater. Distribution water (groundwater) and nanofiltered water were blended at four different ratios (Table 8.1). The 100% distribution water represents the current water in the system.

In order to provide mechanistic insights to changes in corrosivity due to variable chloride and sulfate in the blends, two additional tests were conducted. For one sample of distributed water, chloride (30 mg/L Cl^- from $CaCl_2$) was added to match the chloride level that was present in the 25% distributed and 75% nanofiltered (NF) blend. Likewise, for one sample of 25% distributed and 75% NF water, sulfate (50 mg/L SO_4^{2-} from $CaSO_4$) was added to match the sulfate level present in the 100% distributed water. For all waters, the pH was adjusted with either 0.1 M NaOH or 0.1 M HNO_3 to a target value of pH 8.2 ± 0.1, and the target monochloramine concentration was 2.5 mg/L Cl_2 with a chlorine-to-nitrogen ratio of 5:1 by weight.

Protocol

Simulated lead-copper joints were prepared using a 1-inch in length copper coupling (½-inch diameter copper) with a 1-inch length of 50:50 Pb/Sn solder melted inside (Figure 8.1). Brass coupons (5% lead content) that were ½–inch in diameter were cut in 0.4-inch lengths and epoxied to glass containers (Figure 8.2). The solder-copper couplings were exposed to 100 mL of the six water conditions listed in Table 8.1, and the brass coupons were exposed to 50 mL of each condition. Three replicates were tested for each condition. The water was changed twice

per week (Monday and Thursday), and composite weekly samples were collected for each water condition at the end of each week and analyzed for metals.

Table 8.1
Water conditions tested for Utility K water

Water Blend	**Alkalinity** (mg/L as $CaCO_3$)	**Chloride** (mg/L Cl)	**Sulfate** (mg/L SO_4)	**CSMR**
100% Distribution	125	54	68	0.8
75% Distribution, 25% NF	100	64	52	1.2
50% Distribution, 50% NF	80	72	36	2.0
25% Distribution, 75% NF	65	81	21	3.9
100% Distribution + Cl	125	76	69	1.1
25% Distribution, 75% NF + SO_4	65	75	70	1.1

RESULTS AND DISCUSSION

Lead Release from Brass

Release of lead from the brass dropped somewhat over the six-week testing period in most waters (Figure 8.3) but not as rapidly as has been observed in other waters. Although there were no dramatic differences in trends for the lead levels in brass amongst the different waters, the amount of lead released from the small brass coupons were significant and above the EPA action level of 15 ppb (Figure 8.4). Given that the relatively small volume to surface area for the experimental apparatus versus that present in some faucets, the results are deemed significant relative to the lead and copper rule even considering the atypically long detention time of 3.5 days.

Figure 8.1 Solder-copper coupon used in Utility K study.

Figure 8.2 Brass coupon (5% lead content) in glass for Utility K.

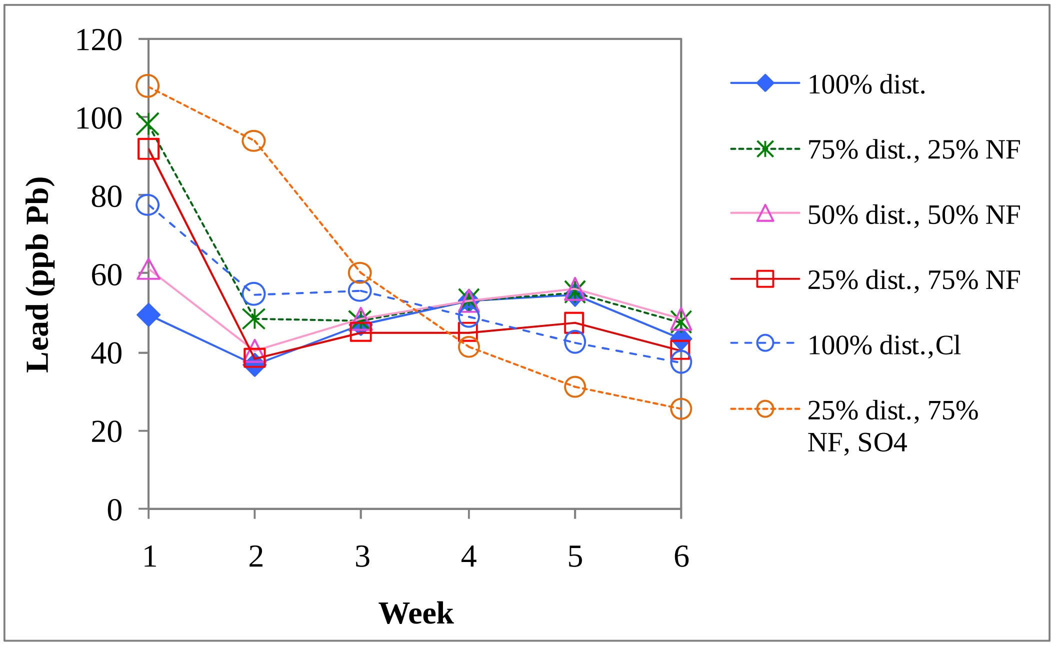


Figure 8.3 Lead release from brass for Utility K water over six weeks.

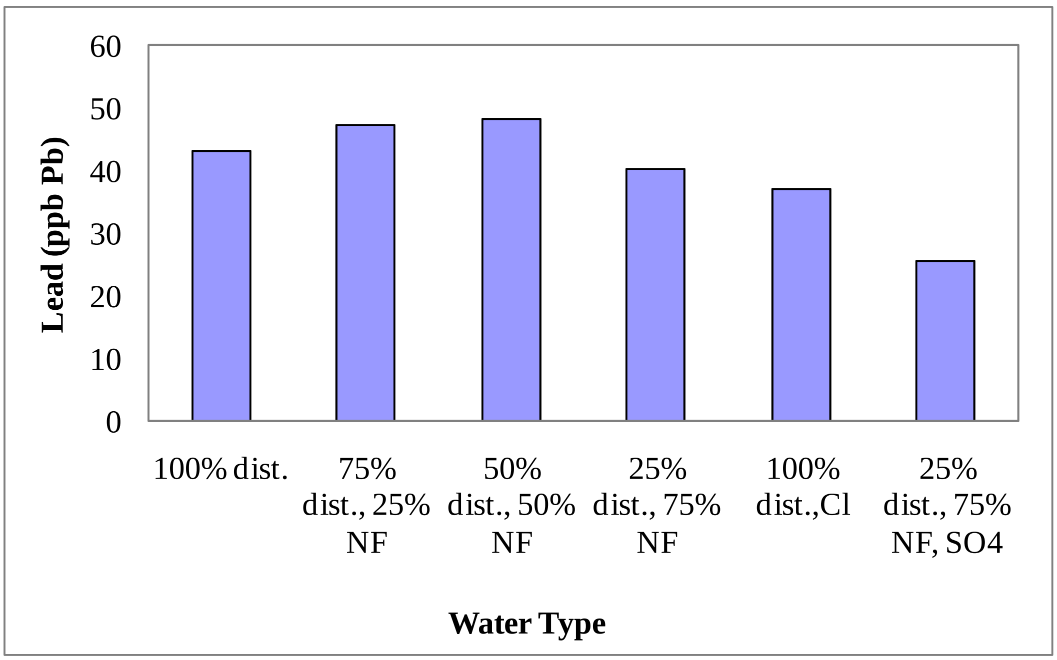


Figure 8.4 Lead release from brass during the sixth week of the Utility K study.

Zinc Release from Brass

Zinc release from brass can be important in determining the longevity of brass products as well as lead leaching. In this case, zinc is also affected by chloride and sulfate since the 75% nanofiltered water had the highest zinc release and the 0% nanofiltered water had the lowest zinc release (Figures 8.5 and 8.6). By adding additional chloride to the distribution water, the zinc was

increased approximately 50%, and the addition of sulfate to the nanofiltered water resulted in a 20% decrease in zinc (Figure 8.6). Thus, dezincification may be slightly impacted by the higher CSMR of the nanofiltered water. Definitive trends will be established in the next few weeks.

Lead Release from Solder

Blending desalinated water with the current distribution water clearly increased lead release from lead solder that is galvanically connected to copper (Figures 8.7 and 8.8). The current distribution water with no desalinated water generated the least amount of lead, while the 75% nanofiltered water sustained lead levels more than 40 times higher than the current distribution water. Even a blend with 25% nanofiltered water increased the amount of lead by 18 times (Figure 8.8).

The increased corrosivity of the nanofiltered water is consistent with expectations based on the high CSMR and the lower alkalinity of the water compared to the groundwater (Table 8.1). Clearly, chloride and sulfate are factors in lead corrosion for the lead solder galvanically coupled to the copper. For example, when the current distribution water was dosed with chloride to equal the chloride concentration in the 75% nanofiltered water, the lead concentration was increased 2.5 times. When the 75% nanofiltered water was dosed with sulfate to match the current distribution water, the lead released was decreased 2.6 times (Figure 8.9).

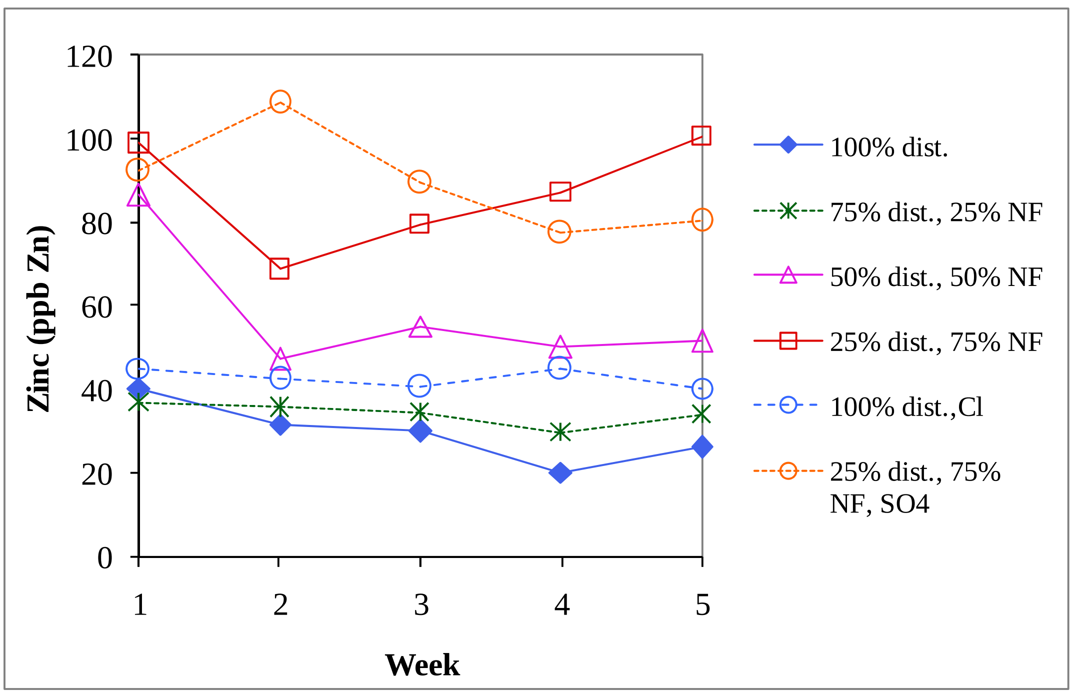


Figure 8.5 The release of zinc from brass over five weeks for Utility K water.

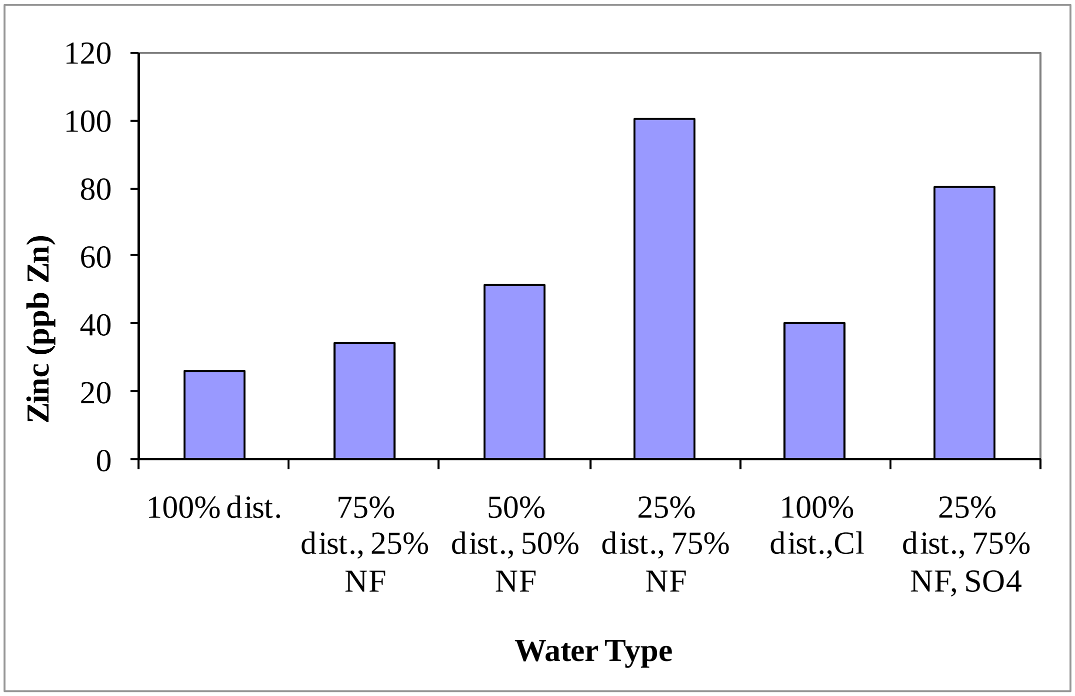


Figure 8.6 The release of zinc from brass during the fifth week of the Utility K study.

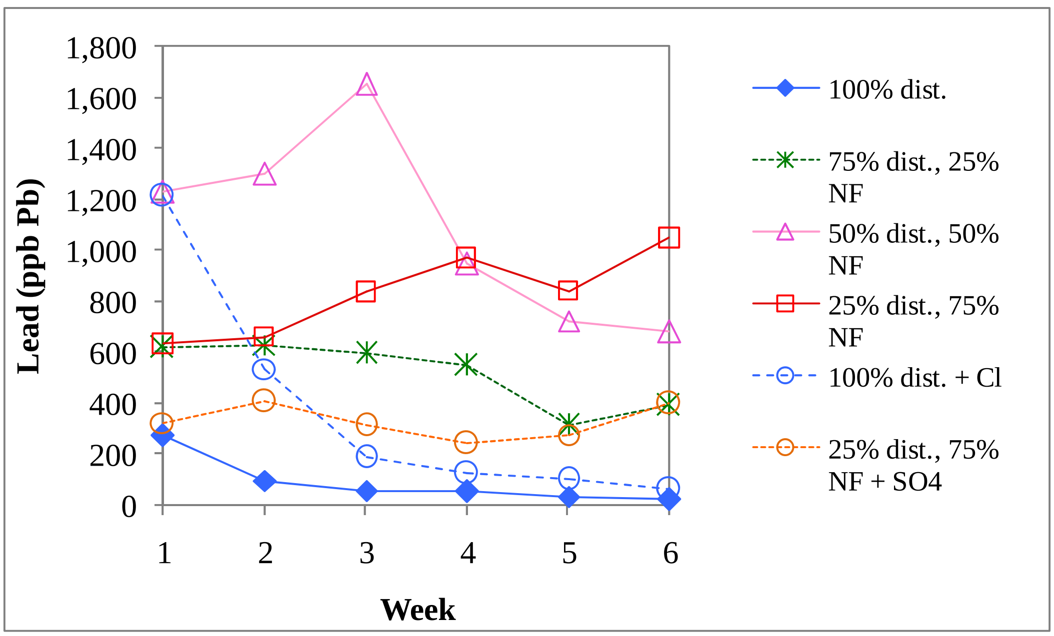


Figure 8.7 Lead release from 50:50 Pb/Sn solder galvanically connected to copper over six weeks when exposed to Utility K water.

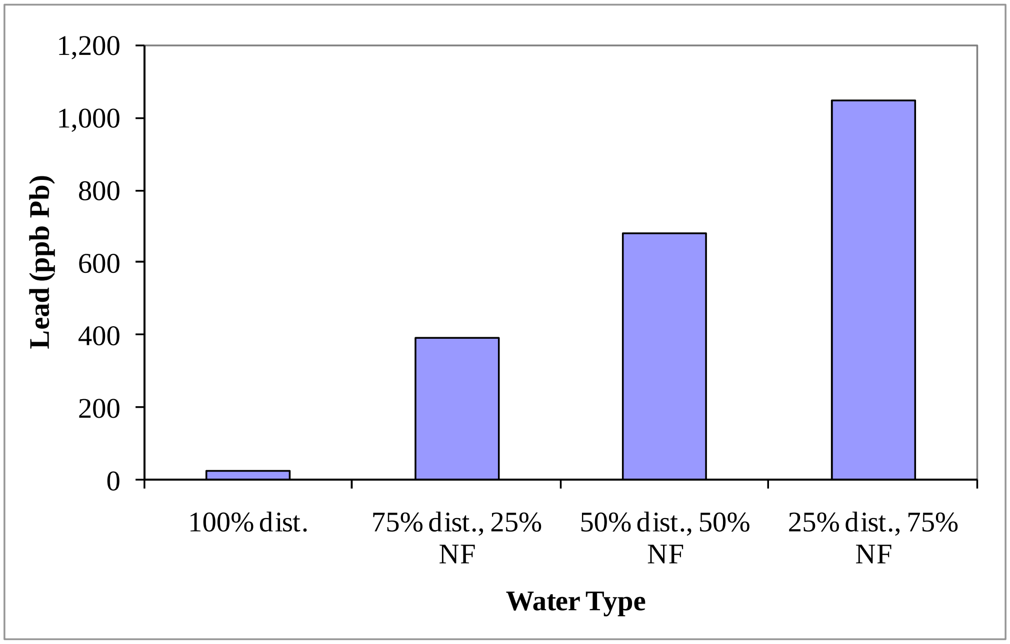


Figure 8.8 Lead release from 50:50 Pb/Sn solder during the sixth week of the Utility K study.

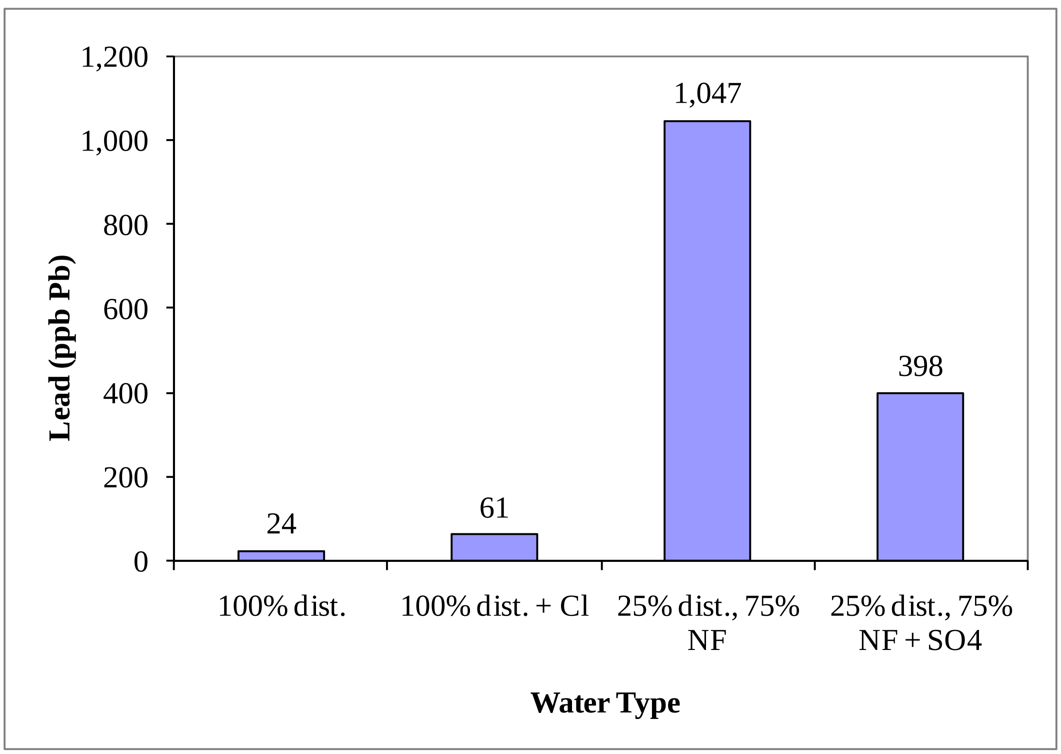


Figure 8.9 Comparison of lead release from 50:50 Pb/Sn solder in 100% distribution water with and without the addition of chloride, and 25% distribution, 75% nanofiltered water with and without the addition of sulfate.

It is also possible that the higher alkalinity in the distribution water buffers pH between the lead solder anode and copper cathode, further contributing to the dramatic difference between the blend and the current water.

CONCLUSIONS

- Blending the desalinated water with the current distributed groundwater dramatically increased the lead levels in Utility K water when exposed to lead solder.
- Lead leaching from brass coupons was not as significantly impacted.
- Amongst the factors that might be tested to mitigate lead solder corrosion in the blends, dosing of orthophosphate, zinc orthophosphate, higher alkalinity, and higher pH are all viable possibilities. It is recommended that additional work be conducted to identify mitigation strategies.

CHAPTER 9
CASE STUDY OF UTILITY F, ME (ARSENIC TREATMENT)

Caroline Nguyen, Kendall Stone, and Marc Edwards

Keywords: anion exchange, arsenic treatment, pH

INTRODUCTION

Extremely high levels of lead were measured at the tap in a community in Maine following installation of anion exchange to remove arsenic from the water. In arsenic treatment via anion exchange, sulfate is removed and replaced with chloride by the resin. As a result, the chloride-to-sulfate mass ratio (CSMR) increases, which is sometimes implicated to higher lead leaching from copper:lead solder galvanic couples (Edwards and Triantafyllidou 2007). One case of lead poisoning was reported in this community after implementing arsenic treatment, and lead levels were documented in the thousands of ppb.

Complicating the interpretation of the data, the anion exchange treatment also reduced the pH of the distributed water to about pH 5.5 for several months due to very frequent regeneration of the exchange resin. The pH was stabilized later at pH 7.8 by stripping CO_2 from the water. In practice, the lead problems were triggered by a number of factors including very low alkalinity, low pH, and higher CSMR.

The objectives of this bench scale study were to (1) evaluate the effect of sulfate removal and chloride addition in arsenic treatment on lead leaching from solder, (2) determine the impact of low pH on lead release from simulated solder-copper pipes, and (3) simulate the period when CO_2 stripping was implemented to increase the pH. Based on conventional wisdom and as occurred in practice, lead leaching was expected to decrease as the pH was increased. By simulating the pH increase at bench scale, the time required before achieving the benefits of higher pH could be approximated. This was not tracked in practice for the case study but could provide valuable information to consumers about the lead reduction time that could be expected. To achieve these objectives, the drinking water was treated with anion exchange to simulate arsenic (and sulfate) removal that triggered the real-world lead problem, and the water was exposed to copper:lead solder couples in bench tests.

MATERIALS AND METHODS

Test Water

Fifteen gallons of water were collected at a point prior to treatment in the community in Maine. Five gallons of this water were subjected to no anion exchange treatment or other further treatment, other than adjusting the pH to 7.0. The remaining ten gallons of water were treated by anion exchange and then adjusted to pH of 7.0 or 5.5 using 0.1 M NaOH for base addition or CO_2 for acid addition. After pH adjustment the water was not treated further, similar to what had occurred in practice. Thus, three water conditions were tested in this study (Table 9.1):

1) control with no arsenic treatment and pH 7.0,

2) water treated with anion exchange, and pH adjusted to 7.0, and
3) water treated with anion exchange, and pH adjusted to 5.5.

Simulated Arsenic Treatment

To simulate arsenic treatment without a column, a chloride-based anion exchange resin was mixed with the water from Utility F, ME (at a ratio of 1.7 mL resin per 1 L of treated water) at 100 rpm for 30 minutes. After settling for 30 minutes, the treated supernatant was used to prepare the two anion exchange water conditions in Table 9.1.

Bio-Rad AG 1-X8 resin (50-100 mesh size) in the chloride form was used for this study. Prior to use, the resin was rinsed thoroughly with deionized water several times to remove excess chloride.

Using this simple anion exchange method, less arsenic and sulfate were removed from the water when compared with anion exchange via a column in practice. As a result, the CSMR after treatment would not be as high as it may be in practice. Thus, any changes observed in this experiment due to the higher CSMR, would likely underestimate the actual impacts if the water had been treated using a column.

Protocol

Copper couplings 1-inch in length and ½-inch in diameter were soldered with 1-inch lengths of 50:50 Pb/Sn solder (Figure 9.1). The coupons were exposed to 100 mL of each of the water conditions listed in Table 9.1. Three replicates were tested for each condition. The water was changed twice per week (Monday and Thursday), and composite weekly samples were collected for each water condition at the end of each week and analyzed for metals. The study was conducted over a 6-week period.

After the initial 6-week study, the pH was increased from pH 5.5 to 7.0 for the arsenic removal condition at low pH to simulate what occurred in practice after the installation an air stripper to increase the pH. The purpose of simulating this at the bench scale was to determine the length of time before the lead release decreased significantly. It was expected that it could be several days or even a couple of weeks after the pH change for lower lead levels to be reached.

Table 9.1
Water quality after indicated water treatment for Utility F

Treatment Type	[As] (µg/L As)	[Cl^-] (mg/L Cl^-)	[SO_4^{2-}] (mg/L SO_4^{2-})	CSMR	Alkalinity (mg/L as $CaCO_3$)	pH
Distribution water	4.5	4.4	4.1	1.1	22	7.0
Distribution water treated with anion exchange	1.8	13.2	1.7	7.8	12	7.0
Distribution water treated with anion exchange and pH reduced	1.8	13.2	1.7	7.8	12	5.5

Figure 9.1 New copper/solder coupons were exposed to Utility F test water.

RESULTS AND DISCUSSION

Effect of Anion Exchange

The most dramatic increase in lead release was observed in water subjected to anion exchange treatment, which had a CSMR of 7.8 at pH 7.0. Treating the water with anion exchange increased lead release an average of 47 times over the 6-week study period from 40 ppb to 1,830 ppb (Figure 9.2). The very high corrosivity of the anion exchange-treated water is attributed to the increase in CSMR, as well as the decrease in alkalinity from 22 mg/L to 12 mg/L as $CaCO_3$, and the results are therefore consistent with practical observations at this site. That is, installation of the arsenic treatment triggered a massive lead contamination event due to lead solder. The marked difference between the anion exchange treatment and no treatment was obvious throughout the study (Figure 9.3).

Effect of Low pH

A smaller but still significant increase in lead release was observed for the anion exchange-treated water at pH 5.5 versus the treated water at pH 7.0. The pH difference of 1.5 units resulted in 2.6 times higher lead leaching at the lower pH condition versus the condition with the same CSMR but pH 7.0 (Figure 9.2). At pH 7, the lead release was 1,800 ppb, while the lead in water was 4,800 for pH 5.5. The results are consistent with theory because lead is more soluble at lower pH.

Recovery Time after Increasing pH from 5.5 to 7

An attempt was made after the first six weeks of the study to determine how quickly the lead leaching would reach a steady state if the pH was increased to 7.0. The lead release decreased dramatically when the pH was increased from pH 5.5 to pH 7. Three weeks after the pH increase, the lead release from the coupons that were changed from pH 5.5 to pH 7 was not significantly different from the amount of lead released from the coupons that were exposed to pH 7 for the entire duration of the study (Figure 9.4).

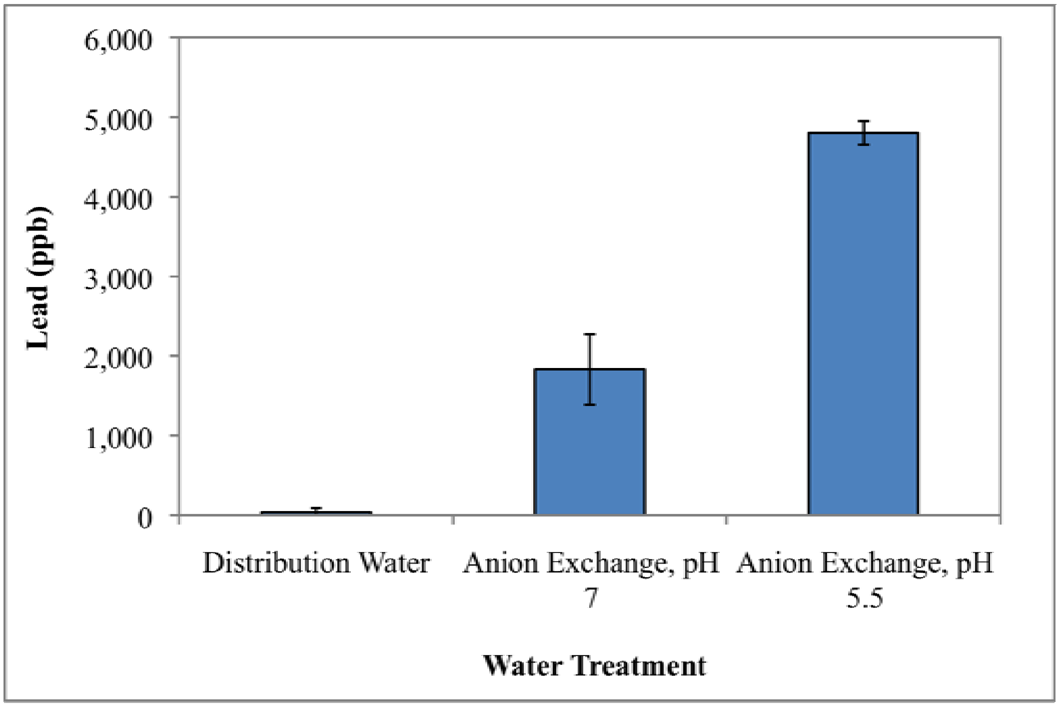


Figure 9.2 Average lead release for each of the three water treatments of Utility F water during the first six weeks of the study. Error bars represent 95% confidence intervals.

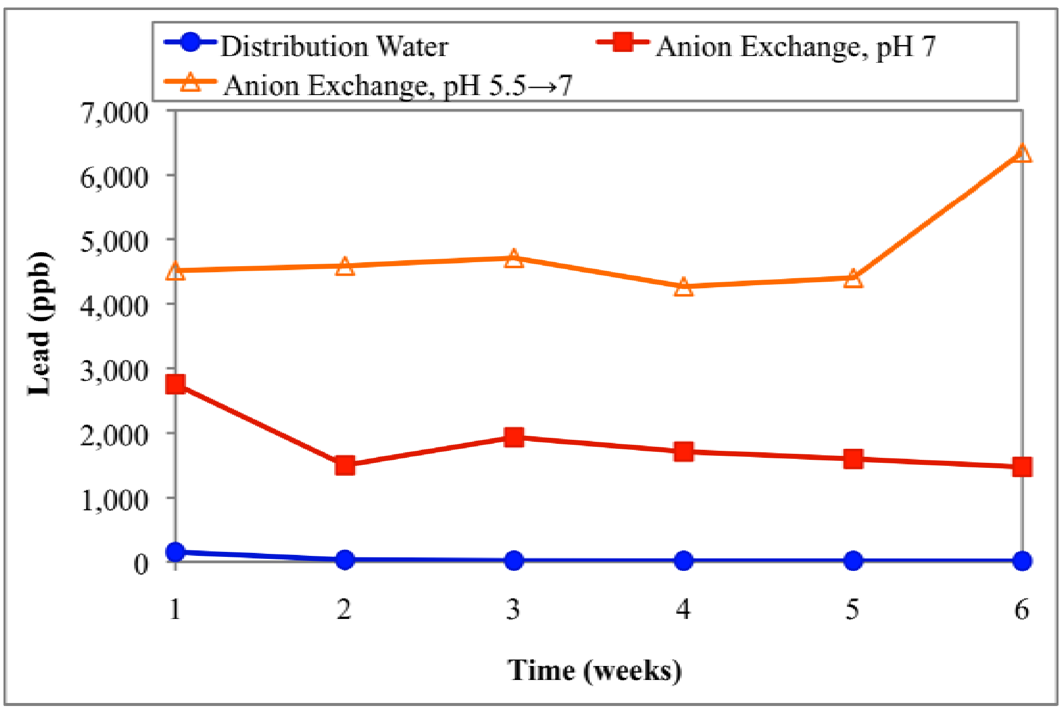


Figure 9.3 Lead release in ppb over the first 6 weeks of the study for Utility F.

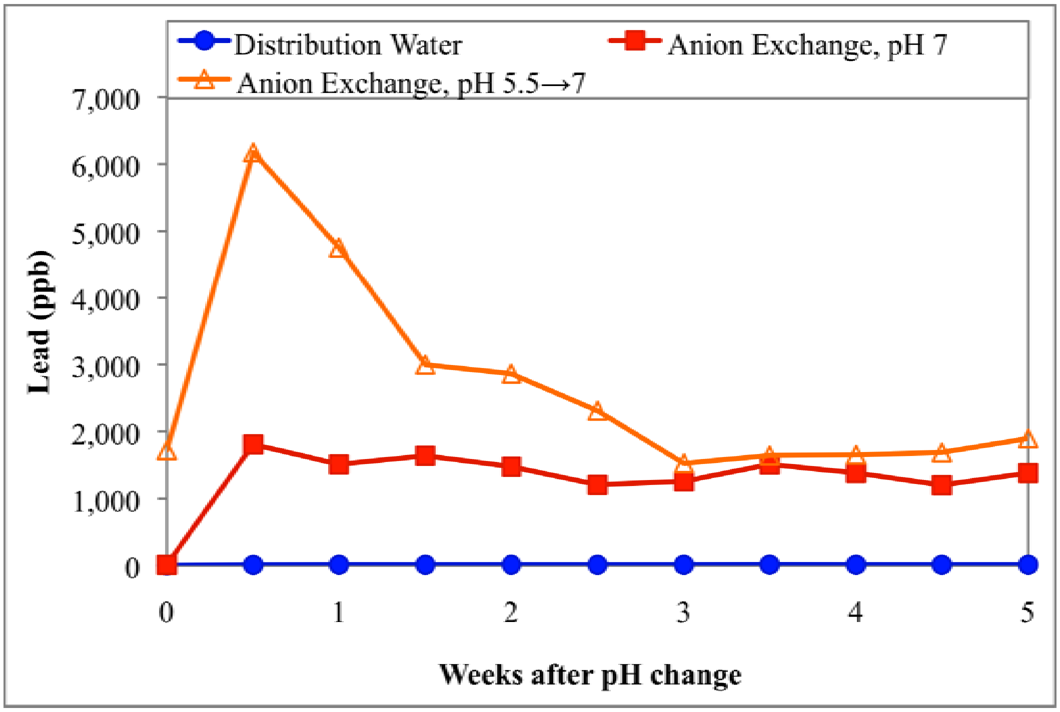


Figure 9.4 Lead release in ppb after pH 5.5 conditions were increased to pH 7

CONCLUSIONS

- Anion exchange treatment and resulting higher CSMR caused a dramatic increase in lead release in this water.
- Anion exchange treated water at pH 5.5 had higher lead release compared to water at pH 7.0, but the pH had a lesser effect on lead leaching compared to anion exchange treatment in the bench scale tests.
- After about 3 weeks, increasing the pH from 5.5 to 7 returned the lead levels to that observed for the water continuously held at pH 7.0

CHAPTER 10
CASE STUDY OF UTILITY J, TN (REMEDIAL STRATEGIES)

Caroline Nguyen, Kendall Stone, and Marc Edwards

Keywords: alkalinity, orthophosphate, polyphosphate, zinc phosphate

INTRODUCTION

Since 2006, Utility J in Tennessee has exceeded the Lead and Copper Rule (LCR) with 90th percentile lead as high as 110 ppb Pb in 2006. Before 2006, utility distributed water at pH 8.7 and had no reported problems with lead. Beginning in 2006, the utility distributed water at pH 7.3 and adding a polyphosphate/orthophosphate blend for corrosion control. Shortly after this change, Utility J began to exceed the LCR (Figure 10.1). Virginia Tech was asked to investigate methods to mitigate the lead problem at Utility J. Virginia Tech was also asked to explore the hypothesis that the lower distribution pH may be contributing to higher lead levels. Nine water conditions were evaluated to determine the effects of various corrosion inhibitors, pH, chloride, sulfate, and alkalinity on the resulting lead released from lead solder galvanically connected to copper pipes. Lead solder is a common culprit of lead in drinking water and is believed to be a dominant source in Utility J.

On the basis of previous studies that pointed to the role of high chloride as a possible contributor to lead in water (Edwards and Triantafyllidou 2007), Utility I determined that chloride levels in their finished water (about 10 ppm and as high as 15 ppm) were much higher than in their raw water (about 2 ppm). This sample result was surprising given that the utility does not use any coagulant such as ferric chloride. Utility personnel traced the higher chloride to a leaky valve in their brine solution that is used to produce free chlorine disinfectant. This leaking valve was fixed as of 2/15/2008, after which time chloride levels in the finished water returned to very low levels.

This utility is not alone, as many utilities across the United States that use on-site hypochlorite generators have measured higher levels of chloride in their waters compared to the use of other chlorine sources, but not necessarily because of brine leaks. In the chlorine generation process, more chloride is produced per unit of free chlorine for on-site hypochlorite generators compared to chlorine gas, and more utilities are switching from chlorine gas to hypochlorite generators because of homeland security concerns. The amount of chloride produced per unit of chlorine disinfectant can be calculated for each chlorine source using the chemical reactions that occur while generating chlorine (Table 10.1). For example, one mole of chlorine gas dissolved in water forms 1 mole of free chlorine (HOCl) and 1 mole of HCl, which dissociates into H^+ and Cl^- in water.

Chlorine gas has the lowest Cl^- to Cl_2 ratio compared to other chlorine sources because every 1 mg/L Cl_2 of dosed from chlorine gas would have approximately 0.5 mg/L Cl^- in the treated water (Table 10.1). In comparison, manufactured hypochlorite solution could have between 0.5 and 0.7 mg/L Cl^- per mg/L Cl_2, where fresh solution ideally contains 0.5 mg/L Cl^- per mg/L Cl_2. In practice, on-site hypochlorite generators produce even more Cl^- per Cl_2, ranging from 0.75 to 2. When monochloramine is used as the disinfectant, the total chlorine residual can be as much as 10 times more than when free chlorine is used. Therefore, the

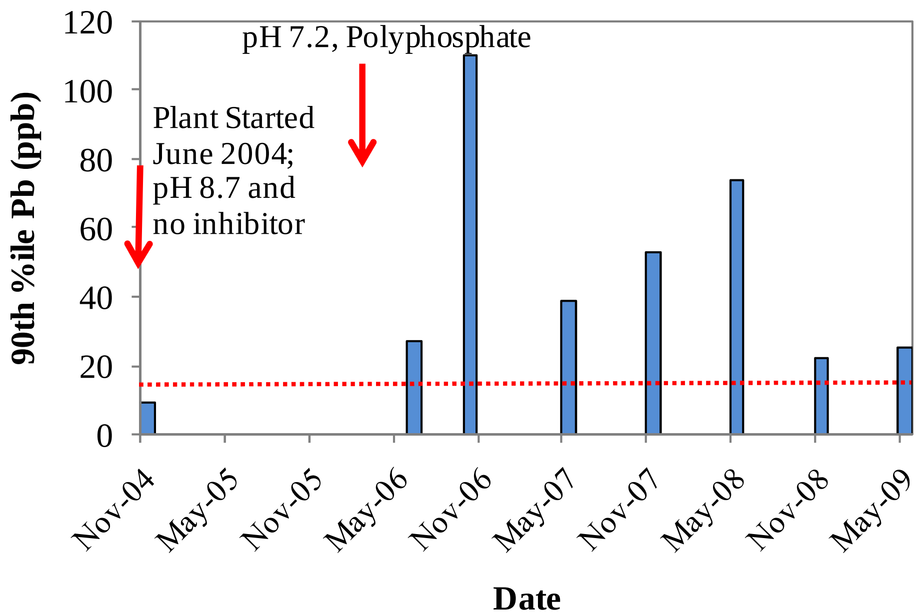


Figure 10.1 Historical 90th percentile lead release data for Utility J. Dotted line indicates the lead action level of 15 ppb.

magnitude of chloride in the water is higher with chloramines, even though the ratio of Cl^- to Cl_2 remains the same. Furthermore, as the chlorine/chloramine disinfectant from any source inherently decays to Cl^- via autodecomposition reactions (Table 10.1), the amount of Cl^- per unit Cl_2 residual eventually rises to infinity.

The objective of the case study for Utility J was to evaluate corrosion remedial strategies, with slightly elevated chloride in their water due to on-site hypochlorite generation.

Table 10.1
Chloride from Disinfection

Method of Chlorination	Sources of Cl^- or Cl_2 Reactions *	Typical mg Cl^- Produced per mg Cl_2
Gas	$Cl_2 + H_2O \rightarrow HOCl + HCl$ $HCl + H_2O \rightarrow H^+ + Cl^-$	0.5
Hypochlorite Solution	$Cl_2 + 2\ NaOH \rightarrow NaOCl + NaCl + H_2O$ (generation) $3\ OCl^- \rightarrow ClO_3^- + 2\ Cl^-$ (auto-decomposition) $2\ OCl^- \rightarrow O_2 + 2\ Cl^-$ (decomposition, catalyzed by metals)	0.5-0.7
Hypochlorite Generator (On-site)	$2NaCl + 2H_2O \rightarrow Cl_2 + NaOH$ $Cl_2 + H_2O \rightarrow HOCl + HCl$	0.75-2 **
Chloramine	Same reactions as above, depending on chlorine source; however, more Cl_2 is typically added (10X more than free chlorine)	0.5-2, depending on chlorine source

* AWWA 2006 ** MIOX

MATERIALS AND METHODS

Test Water

Test water was obtained at Virginia Tech by shipments of Utility J treated water from the UV channel of the treatment plant. Collected water was separated into aliquots and subjected to various treatments (Table 10.2). Chemicals added to the water included orthophosphate corrosion inhibitor with or without zinc, polyphosphate/orthophosphate blend, bicarbonate, sulfate, disinfection with free chlorine, and acid or base for final pH adjustment. All waters (unless specified) were dosed with 3 mg/L Cl to simulate a portion of the chloride that entered the water due to the hypochlorite generator.

The pH was adjusted with either 0.1 M NaOH or 0.1 M HNO_3 to the target value of pH 7.3 or 8.7. All water was also dosed with free chlorine at a concentration of 2 mg/L Cl_2. Utility J provided the poly-orthophosphate blend corrosion inhibitor, which is currently used by the utility. Orthophosphate was dosed from sodium phosphate (Na_2HPO_4), and zinc was added as zinc sulfate ($ZnSO_4$). Alkalinity was adjusted with sodium bicarbonate ($NaHCO_3$). Chloride and sulfate were added from sodium chloride (NaCl) and sodium sulfate (Na_2SO_4).

Table 10.2
Water quality conditions tested for Utility J water after addition of 3 mg/L Cl^-

Water Type	pH	Conductivity (µS)	Alkalinity (mg/L as $CaCO_3$)	Chloride (mg/L Cl)	Sulfate (mg/L SO_4)	Silica (mg/L Si)	Phosphate (mg/L P)
pH 8.7	8.7	48	8	10.0	2.4	2.1	0.0
pH 7.3	7.3	190	8	10.0	1.7	2.3	0.0
pH 7.3, 20 mg/L as $CaCO_3$	7.3	49	20	7.5	2.6	2.3	0.0
pH 7.3, 1 mg/L PO_4 as P, 20 mg/L as $CaCO_3$	7.3	55	20	7.5	2.4	2.2	1.0
pH 7.3, 1 mg/L PO_4 as P	7.3	55	8	8.0	2.4	2.2	1.0
pH 7.3, 1 mg/L PO_4 as P, 100 µg/L Zn	7.3	70	8	7.6	2.7	2.2	1.0
pH 7.3, 1 mg/L PO_4 as P, 300 µg/L Zn	7.3	76	8	7.5	3.1	2.3	1.0
pH 7.3, poly-orthophosphate inhibitor	7.3	54	8	7.5	2.0	2.3	0.2
pH 7.3, 15 mg/L Cl, 45 mg/L SO_4	7.3	53	8	19.2	55.1	2.4	0.0

Protocol

A 1" length of 50:50 Pb/Sn solder was melted within a 1" length of ½" diameter copper couplings (Figure 10.2). The solder-copper couplings were exposed to 100 mL of the nine water conditions listed in Table 10.2. Three replicates were performed for each water condition. The

water was changed twice per week (Tuesday and Friday), and composite weekly samples were collected for each water condition at the end of each week and analyzed for lead. Therefore, the lead values were a composite average of a 3.5-day (Tuesday through Friday) and 4-day (Friday through Tuesday) stagnation.

RESULTS AND DISCUSSION

Effect of Phosphate Inhibitors

The addition of 1 mg/L orthophosphate as P to the Utility J water produced water with the lowest lead levels compared to other treatments evaluated in this study (Figure 10.3 and Table 10.3). By switching from the current corrosion inhibitor, which is a poly-orthophosphate blend, to orthophosphate the lead concentration could be reduced by about 75%. Waters with orthophosphate consistently had lower lead levels than the other conditions after the third week of the study (Figure 10.4). The addition of zinc as a corrosion inhibitor did not provide a greater benefit than when orthophosphate alone was added after the first few weeks, although the zinc seemed to have a short-term benefit during the first month of the study (Figure 10.4).

Figure 10.2 Solder-copper coupons exposed to Utility J test water.

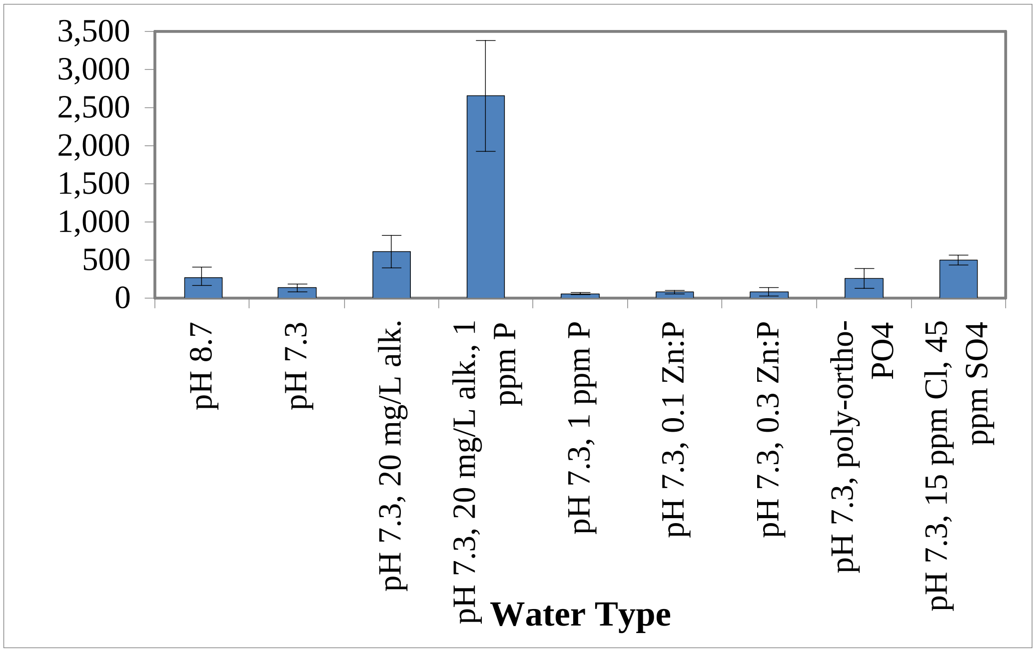


Figure 10.3 Average lead released for each water condition during the eighth week of the Utility J study. The error bars represent 90% confidence intervals based on data from the replicates.

Effect of pH

Contrary to the initial hypothesis, which was that the high lead may have been triggered by changing the corrosion control strategy from a pH of 8.7 without inhibitor to pH 7.3 with phosphate inhibitor, lead leaching at pH 8.7 was not lower than at pH 7.3 with inhibitor. It is therefore considered likely that the high lead was triggered by a leak of chloride from the valve starting sometime before July 2006.

Table 10.3
Average lead values for the eighth week of the Utility J study (±95% confidence interval).

Water Type	Average Lead (ppb)
pH 8.7	287 ±120
pH 7.3	134 ±50
pH 7.3, 20 mg/L as $CaCO_3$	609 ±210
pH 7.3, 20 mg/L as $CaCO_3$, 1 mg/L P	2,657 ±720
pH 7.3, 1 mg/L P	57 ±10
pH 7.3, 1 mg/L P, 100 µg/L Zn (or 0.1 Zn:P)	81 ±20
pH 7.3, 1 mg/L P, 300 µg/L Zn (or 0.3 Zn:P)	85 ±60
pH 7.3, 2 mg/L poly-orthophosphate	261 ±130
pH 7.3, 15 mg/L Cl, 45 mg/L SO_4	499 ±60

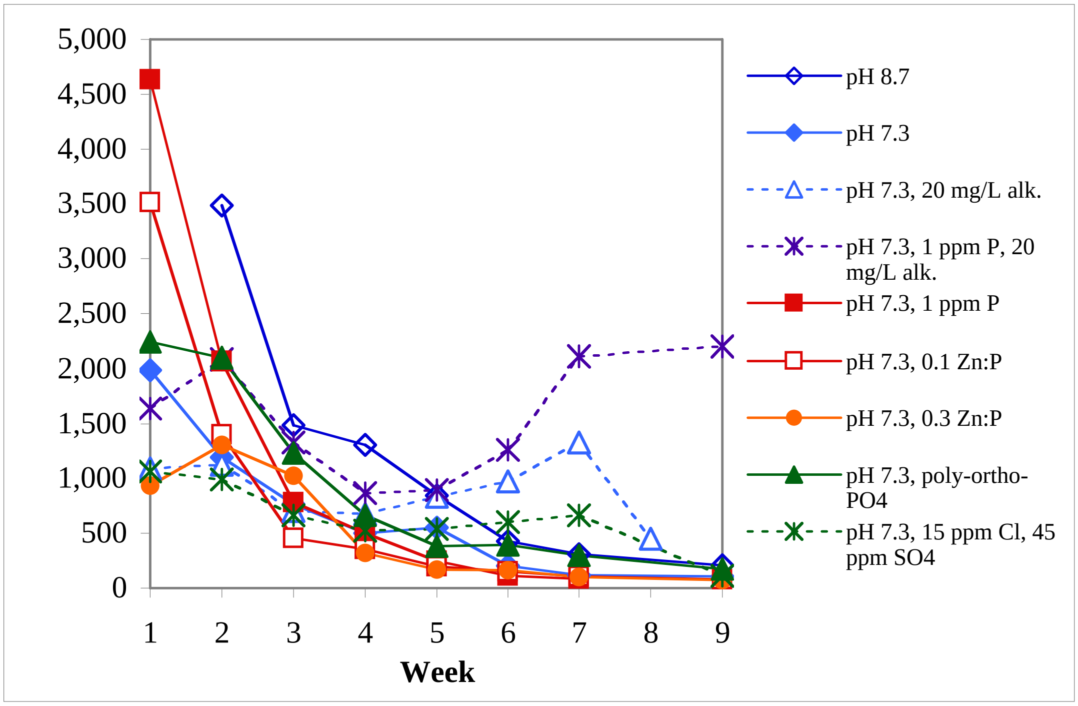


Figure 10.4 Lead concentrations throughout the nine-week study for Utility J water.

Effect of Alkalinity

It was also surprising that contrary to current expectations, increasing the alkalinity slightly from around 10 mg/L as $CaCO_3$ to 20 mg/L as $CaCO_3$ appeared to dramatically worsen the lead released from the solder-copper couplings. Clearly, addition of alkalinity will not solve lead problems at Utility J and would actually make the situation worse. These results are very interesting, and future intensive additional experiments will be conducted to gain mechanistic insights. It is possible that higher alkalinity does not always reduce the magnitude of this problem.

pH Microelectrode Measurements

The galvanic interaction between the copper-solder couplings causes a dramatic local drop in pH of water next to the solder surface (Figure 10.5), as measured with a microelectrode. This drop is caused by the galvanic current between lead and the copper, and is a large contributor to the high levels of lead in this system. However, unlike prior results, there is no correlation between the pH measured at the lead surface and the amount of lead leached to the water (Figure 10.6). In this particular water, which has extremely low conductivity (Table 10.2), it is believed that the total amount of salt in the water may play a decisive role in controlling lead release.

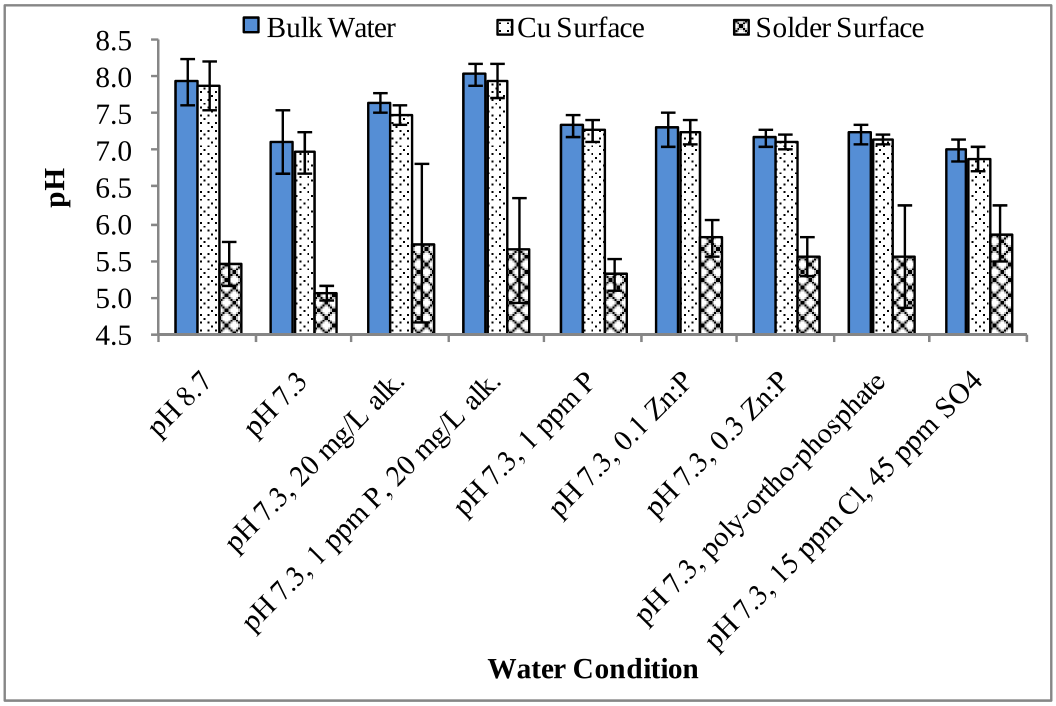


Figure 10.5 Local pH measurements taken during the 14th week of the study for Utility J. The error bars represent the 90% confidence interval based on data collected from the triplicates.

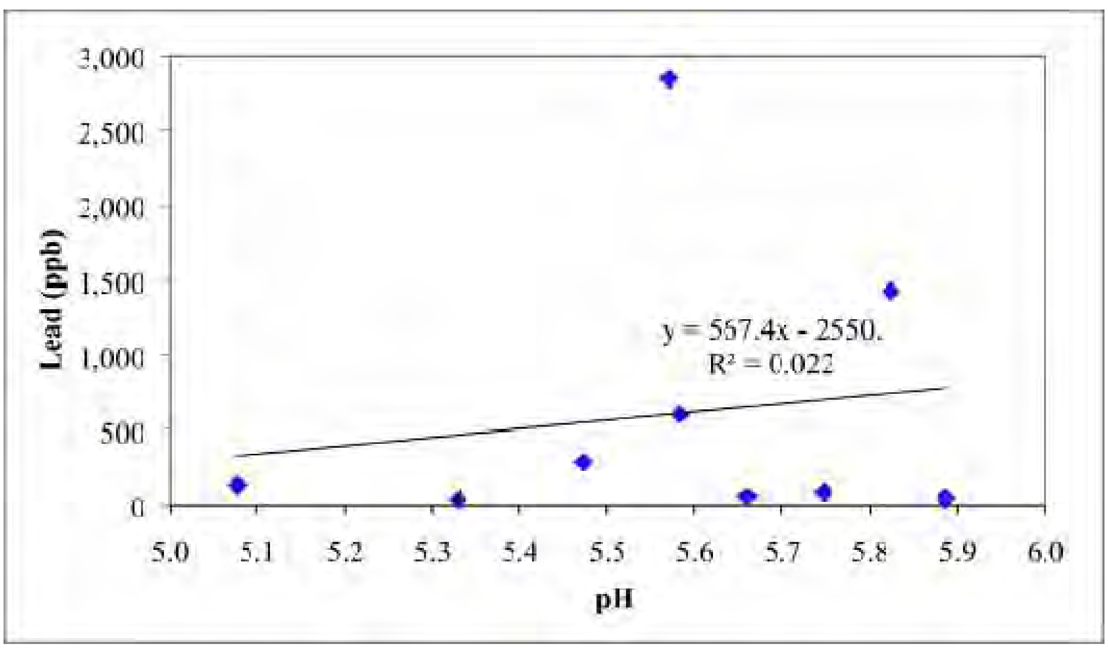


Figure 10.6 Lead release plotted against pH at the solder surface for Utility J water.

CONCLUSIONS

- Changing the pH from 8.7 to 7.3 did not have an effect on lead release.
- Galvanic interactions between copper and solder, indicated by a local pH drop at the solder surface, caused a leaching of lead into the water.
- The lead release was lessened by the addition of orthophosphate corrosion inhibitor.
- Addition of alkalinity had no positive effect on lead release. Addition of zinc had no additional benefit.
- There was no correlation between pH at the solder surface and lead release.

The recommendation is that Utility J immediately should begin dosing orthophosphate at a dose of 1 mg/L P (3 mg/L PO_4). After a few months dosing this would likely bring the utility into compliance with the LCR (now that higher Cl^- in the water is no longer a problem), and the utility could then consider decreasing the orthophosphate dose to the more typical level of 0.33 mg/L P (1 mg/L PO_4) to reduce costs.

CHAPTER 11
UTILITY H, WA (PIPE LOOP STUDY)

Prepared by Anne Sandvig and Reviewed by Glenn Boyd

Keywords: CSMR, flow, bronze, lead pipe, solder, passivation

INTRODUCTION

The objective of this part of the research was to evaluate the effects of high and low chloride-to-sulfate mass ratio (CSMR) on release of lead from a variety of lead plumbing materials found in distribution and premise piping (i.e., lead pipe, brass pipe, lead solder joints) utilizing a recirculating pipe loop apparatus. The water used for these experiments contained phosphate at approximately 1 mg/L and the pH was adjusted to 7.0-7.5. These conditions were selected to simulate optimal corrosion control treatment using phosphates, to evaluate the impact of changes in CSMR on lead release under these conditions. Both single metal and dual metal pipe loops containing leaded materials were evaluated. During the testing the occurrence of particulate lead in the reservoirs and the potential for sorption of lead onto the reservoirs used in the testing apparatus were evaluated.

MATERIALS AND METHODS

Pipe Loop Setup and Materials

Pipe loop testing was conducted at the HDR Applied Research and Technology Center (ARTC) facility in Redmond, WA. The testing involved the use of lead pipe segments recovered from a local service area in Washington, simulated lead solder joints (fabricated at Virginia Tech), bronze piping (containing 7% lead by weight), and new copper tubing. Pipe loops were constructed using these plumbing materials to study the effects of changes in the CSMR of the influent water on lead release from the metal pipe loop sections. The pipe loop set-up consisted of both single and dual-metal pipe loop sections. Each loop was designed to recirculate target water quality conditions, and a timer was installed on each loop to control on/off cycling of the water flow.

The pipe loops were assembled in March 2008, and testing was conducted from April 21, 2008 through September 4, 2008. A schematic of the recirculating pipe loop setup at the ARTC facility is shown in Figure 11.1, with photographs of the individual pipe loop sections shown in Figures 11.2 through 11.8. As shown in Figure 11.1, the pipe loops were categorized as:

- Series (setup) A – single metal series
- Series (setup) B – galvanic series (dual metals)

The lead materials tested in the pipe loops included lead pipe, bronze pipe, and simulated lead solder joints. Lead and bronze pipe sections used in these pipe loops were previously used in a separate Water Research Foundation study, Project 3107 (Boyd et al. 2010), and modified for this study, Project 4088.

Pipe Materials

Lead Pipe. Lead pipe sections consisted of lead goosenecks recovered from the existing distribution system of Utility H, WA and were ¾" in diameter. The inside surfaces of some of these lead pipe segments had been reamed prior to use in the previous Foundation project (newer passivated lead pipe), while others had not (older passivated lead pipe). Therefore, the older passivated pipes had variable histories of scale exposure to differing water qualities over time in the distribution system as well as the varying water quality conditions of exposure under the previous Foundation project testing conditions (changes in chlorine, chloramines, pH, alkalinity, PO_4 concentration). The newer passivated pipes had been reamed prior to use in the WaterRF Project 3107, and therefore the internal surface of the pipes had been exposed to the varying water quality testing conditions for the previous study.

Bronze Pipe. Bronze pipe (containing 7% lead) (passivated bronze) was originally purchased from Spectrum Machine, Inc., Streetsboro, Ohio. They were used as part of a previous Foundation study (Boyd et al. 2010) and then retrofitted into the pipe loop design for this study. The bronze pipe contained 7% Pb (C93200 tube, ¾" ID), which was used as a surrogate for standard brass typically used in distribution and premise piping containing up to 8% Pb, as brass pipe containing 8% Pb was not commercially available.

Copper Pipe. New, ¾" diameter type M copper pipe was purchased from a local supplier. The copper pipes were used in the dual metal loops and connected to the lead-bearing pipes.

Simulated Lead Solder Joints. Virginia Tech provided simulated lead soldered joints. Two sampling ports ½" in diameter were drilled in 3" long new copper pipe sections. The copper pipe sections were then dipped into liquid non-corrosive flux and into molten 50:50 lead:tin solder. The solder formed a continuous coating in the inner and outer surfaces of each copper section so that no copper was showing.

Description of Loops

The Series A single-metal pipe loops were labeled Loops 1 and 2 (Figures 11.2 and 11.3). Each of these loops consisted of one 12" length of a specific lead bearing pipe material, either newer passivated lead (Loop 1) or passivated bronze (Loop 2) which served as the source of lead release. For the Series B, dual-metal pipe loops, Loops 3 through 5 consisted of one 12" length of lead bearing material (older passivated lead pipe, newer passivated lead pipe, passivated bronze pipe) and 36" of new copper pipe (Figures 11.4, 11.5, and 11.6). This configuration provided approximately three times the surface area of copper to lead bearing material.

Loop 6 contained two 3" long simulated lead solder joints and 12" sections of copper pipe between each simulated joint, or a total of 36" of copper pipe (Figure 11.7). Loop 7 (Figures 11.1 and 11.8) contained only simulated lead solder joints. The plumbing materials used for each of the loops are summarized in Table 11.1. Thin, non-metallic spacers were placed between each of the pipe-to-pipe connections in the Series B, dual-metal pipe loops. For Loops 3, 4 and 5 a PVC spacer was used, and for Loops 6 and 7, fiber spacers were used. The spacers allow the galvanic current (that normally flows from one pipe section to another) to be quantified with an ammeter.

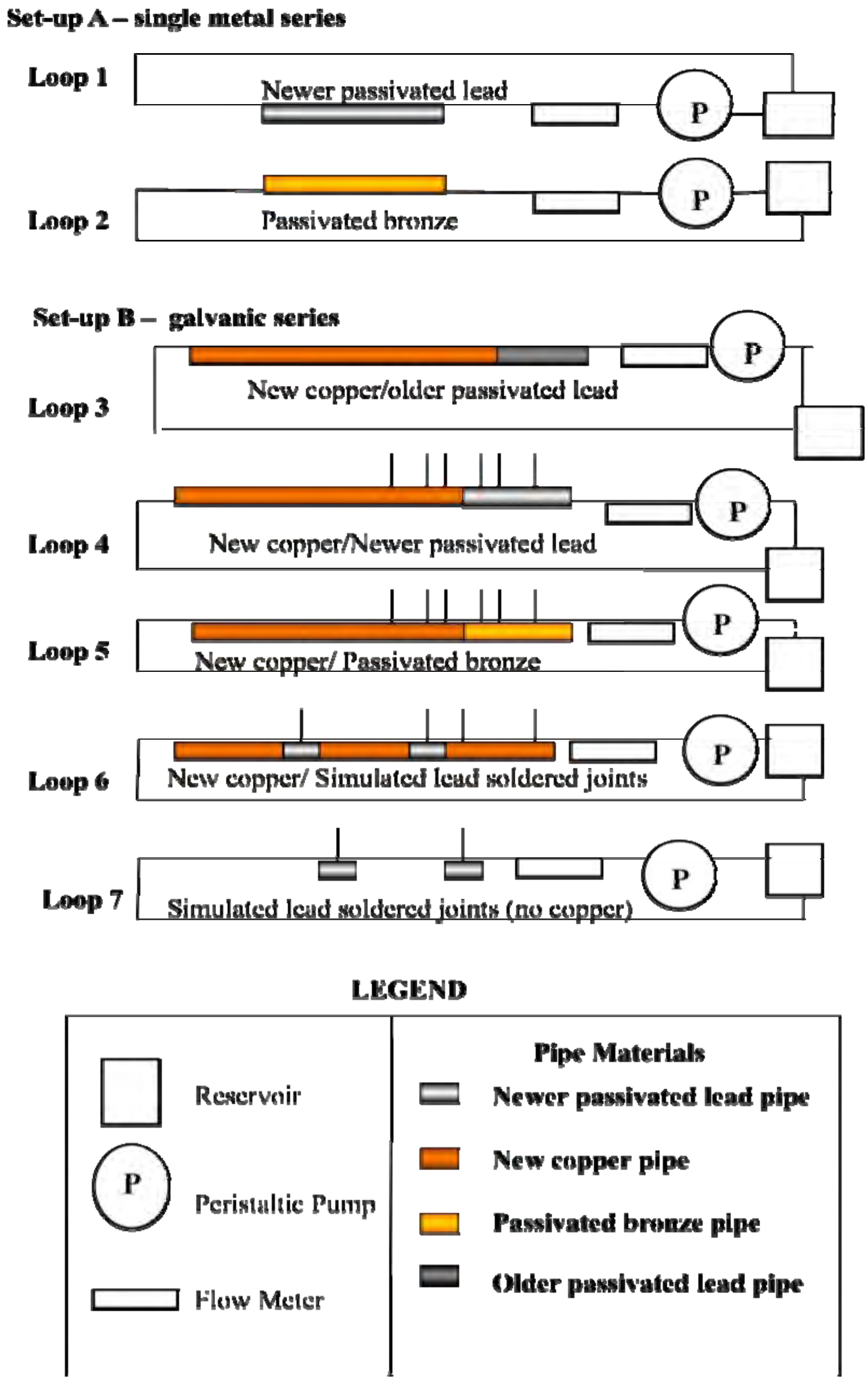


Figure 11.1 Pipe Loop Setup

Each pipe loop was equipped with a dedicated March magnetic impeller drive recirculating pump, PVC flow-control valve, King acrylic body (stainless steel flow indicator) flow meter, and a 20-L fluorinated polyethylene lined Nalgene water reservoir. Separate components (metal and non-metal) in the pipe loop setups were all connected using flexible tubing (Tygon SE200 for reservoir to pump, Tygon 2075 for all other connections). Flexible tubing was compressed around the exterior of the joints using stainless steel pipe clamps. A constant volumetric flow rate of 0.5 gpm was maintained throughout the course of the investigation, except during stagnation events as discussed in later text.

Prior to the start of the study, the reservoirs and tubing were cleaned (without metal sections attached) by adding nitric acid (Integra Scientific N767.10.40P (68-70%)) to each reservoir to create a 2% solution based on existing volume of water already in each reservoir (no additional water was added). This 2% nitric acid solution was recirculated through each loop including the reservoir and tubing for 2 days. After cleaning, the apparatus was neutralized by recirculating 10 mM sodium bicarbonate solution through the reservoir and tubing for 3 hours. After careful rinsing the metal sections were then incorporated into each loop.

Small ports were made by drilling 9/16" holes (1/2" holes for simulated lead solder sections) at intervals along the length of the metal pipe sections and simulated lead soldered joints for Loops 4 through 7 to allow for measurements inside the metal pipe sections (ex., pH). For Loops 4 and 5, these ports were centered at 1", 2", and 4" from the connection point between the two dissimilar metals. For Loops 6 and 7, the ports were drilled into the simulated lead soldered joints at locations ¾" from each end. Loop 6 also had 9/16" holes drilled, which were centered at 1" from each end of the copper pipe located on the inflow side. When not in use, ports were sealed (plugged) with FDA approved high purity silicone stoppers (Cole Parmer #R62994). Figure 11.1 displays the approximate locations of these ports.

Test Water

Local tap water was supplied by Utility H for all testing (Table 11.2), and the water was flushed for 3-5 minutes prior to filling the 200 L reservoir that was used to store water for the testing. The water chemistry in the 200-L reservoir was adjusted to provide the target chloride/

Table 11.1
Pipe Loop Designations and Materials

Pipe Loop Designation	Pipe Material	Length
1	Newer passivated lead pipe	12"
2	Passivated bronze pipe	12"
3	Older passivated lead pipe Copper pipe	12" 36"
4	Newer passivated lead pipe Copper pipe	12" 36"
5	Passivated bronze pipe Copper pipe	12" 36"
6	Simulated lead solder joints Copper pipe	3" (2 joints total) 3 – 12" lengths (36" total)
7	Simulated lead solder joints	3" (2 joints total)

Figure 11.2 Loop 1 – Newer Passivated Lead Pipe

Figure 11.3 Loop 2 - Passivated Bronze Pipe

Figure 11.4 Loop 3 - New Copper Pipe Connected to Older Passivated Lead Pipe

Figure 11.5 Loop 4 - New Copper Pipe Connected to Newer Passivated Lead Pipe

Figure 11.6 Loop 5 - New Copper Pipe and Passivated Bronze Pipe

Figure 11.7 Loop 6 - New Copper Pipe and Simulated Lead Solder Joint

Figure 11.8 Loop 7 - Simulated Lead Solder Joint Without Connection to Copper Pipe

Table 11.2
Background Water Quality for Utility H

Water Quality Parameter	Typical
pH range	8.27 – 8.72
Alkalinity, total (mg/L as $CaCO_3$)	19
Hardness (mg/L as $CaCO_3$)	28
TOC (mg/L)	0.9
TDS (mg/L)	41
Specific conductance (µmhos/cm)	64.4
Chloride (mg/L)	3
Sulfate (mg/L)	1.5
Chlorine residual (mg/L as Cl_2)[b]	0.86
Phosphate, soluble reactive (µg/L)	3

sulfate ratio, disinfectant residual, pH, phosphate, and alkalinity levels required for each test condition. The adjusted test water was prepared once per week and then transferred into a separate recirculating test water reservoir for each loop.

Water quality parameters (pH, temperature, total chlorine) were measured approximately 5-7 times per week and adjusted further in each of the recirculating pipe loops as needed to maintain the targeted water quality conditions. The chloride-to-sulfate ratio of the water was adjusted by addition of NaCl at the beginning of the week. Chloride and sulfate were also monitored and NaCl was added in an effort to maintain the target chloride-to-sulfate ratio for each batch of water. Phosphate levels were adjusted to approximately 1.0 mg/L PO_4 and were not adjusted for each batch of water. Resultant phosphate levels were measured at the end of each test period prior to the water change. Detailed measurements of pH, alkalinity, chlorine, and chloride-to-sulfate mass ratio are included in Appendix B (Figures B.1 through B.4).

Table 11.3 lists the operational water quality parameters that were monitored during the course of the study. Typically, pH trended higher in each loop over time, and was adjusted to a pH between 7.0 and 7.5 with the addition of 1.0 N HCl.

Table 11.3
Operational Water Quality Parameter Measurements

Water Quality Parameter	Frequency Measured	Method Used
pH and Temperature	5-7 times per week	pH sensor electrode in conjunction with an electronic IQ Scientific IQ150 pH/mV/temperature meter
Total Chlorine	5-7 times per week	Hach DR/4000 spectrophotometer Hach Method 8167 for total-chlorine, utilizing DPD.
Total Alkalinity	Weekly	Hach Method: Digital titration of H_2SO_4 to a pH end point of 4.9
Chloride	Weekly*	Hach Method 8206: Mercuric Thiocyanate Method 8113. using Hach DR 2800
Sulfate	Weekly*	Hach Method 8051: Spectrophotometry at 450nm with SulfaVer Powder Pillows
Phosphate	Weekly	Hach DR/4000 spectrophotometer Hach Method 8048

*at a minimum

Description of Testing Sequence

Testing began in the HDR ARTC facility on April 21, 2008. Six test sequences were conducted (Table 11.4). All seven pipe loops were operated simultaneously during each of the six test sequences. For each test sequence, pH, alkalinity, phosphate, and total chlorine levels were maintained as displayed in Table 11.5. The only water quality parameters that were altered for the various test sequences were chloride and sulfate levels to achieve either a high (~8-12) or low (~1-2) CSMR. Water was adjusted in the 200-L tank and then transferred to the 20-L reservoirs for each loop. The CSMR was adjusted to the specific target conditions for each test, and different flow regimes were established (continuous flow versus different stagnation periods). The contents of the 20-L recirculating pipe-loop reservoir were replenished with freshly prepared treated water on a weekly basis.

Test 1 characterized metals release for the pipe materials under a CSMR of approximately 1 - 2 (low CSMR) under continuous flow conditions. For Test 2, the CSMR was maintained at this low chloride/sulfate ratio and flow was adjusted so that water was stagnant with the exception of a 5-minute flow period every 8 hours (long stagnation period). For Test 3, the CSMR was adjusted to approximately 8-10 (high CSMR), and the flow was adjusted so that water was flowing with the exception of a 5-minute stagnation period every 8 hours (short

Table 11.4
Test Sequence for Recirculating Pipe Loop Study at the HDR ARTC Facility

Test No.	Chloride/Sulfate Ratio	Flow/Stagnation Conditions	Start Date	End Date
1	Low chloride/sulfate ratio	Continuous Flow	April 30, 2008	May 14, 2008
2	Low chloride/sulfate ratio	Long Stagnation (5 minute flow every 8 hours)	May 14, 2008	May 28. 2008
3	High chloride/sulfate ratio	Short Stagnation (5 minute stagnation every 8 hours)	May 28, 2008	July 23, 2008
4	High chloride/sulfate ratio	Long Stagnation (5 minute flow every 8 hours)	July 28, 2008	Aug. 11, 2008
5*	High chloride/sulfate ratio	Long Stagnation (5 minute flow every 8 hours)	Aug. 14, 2008	Aug. 21, 2008
6*	Low chloride/sulfate ratio	Long Stagnation (5 minute flow every 8 hours)	Aug. 25, 2008	Sept. 2, 2008

*Reservoirs were acid cleaned prior to these tests.

Table 11.5
Target Water Quality Conditions for Each Test Sequence

Test No.	pH	Alkalinity, mg/L as $CaCO_3$	Total Chlorine (chloramines), mg/L	Phosphate, mg/L as PO_4	CSMR
1	7.0 – 7.5	20	3.5	1.0	1-2
2	7.0 – 7.5	20	3.5	1.0	1-2
3	7.0 – 7.5	20	3.5	1.0	8-10
4	7.0 – 7.5	20	3.5	1.0	8-10
5	7.0 – 7.5	20	3.5	1.0	8-10
6	7.0 – 7.5	20	3.5	1.0	1-2

stagnation period). Test 3 was conducted for eight weeks, in order to establish stability in the pipe sections under high CSMR conditions. The original test plan called for a long stagnation period for Test 3 (5 minute flow period every 8 hours); however, an error in the written testing plan resulted in the short stagnation period being implemented. Preliminary data evaluation conducted at the end of Test 3 raised questions about 1) possible lead sorption onto the 20-L Nalgene reservoirs, which could impact lead levels measured from the loops during recirculating flow conditions, and 2) particulate lead potentially developing in the reservoirs. A series of special samples were collected at the end of Test 3 to evaluate these issues, and a revised testing protocol was developed for the end of Test 4 and for Tests 5 and 6 to evaluate the effects of CSMR, the occurrence of particulate lead in the reservoirs, and the potential for sorption of lead onto the Nalgene reservoirs.

For Test 4, the chloride-to-sulfate ratio was maintained at approximately 8-10 (high CSMR), and the flow was adjusted so that water was stagnant with the exception of a 5-minute flow period every 8 hours (long stagnation period). Test 4 continued for approximately 2 weeks, after which the reservoirs were disconnected from the metal pipe loop sections. The reservoirs were cleaned by adding nitric acid to obtain a 2% nitric acid solution in each reservoir, which was maintained for 24 hours. After 24 hours, a sample was collected from each reservoir, after which the reservoirs were thoroughly rinsed with distilled water prior to the start of Test 5.

The water condition evaluated in Test 5 was the same as in Test 4 with a CSMR of 10 (high CSMR) and a 5-minute flow period every 8 hours (long stagnation period); however, the reservoir had been acid-cleaned prior to the start of Test 5. Flowing reservoir and stagnant pipe samples were taken under these conditions for approximately one week. At the end of Test 5, flowing samples were collected from the top of each reservoir, the reservoirs were disconnected from each loop, and an additional sample was collected from the middle of each reservoir after the water inside had been mixed. Each of the reservoirs was again cleaned using nitric acid, and rinsed with distilled water as described above, prior to the start of Test 6. The final test condition, Test 6, consisted of a CSMR of approximately 1-2 (low CSMR) with a 5-minute flow period every 8 hours (long stagnation period). This test condition was continued for one week.

Lead and Electrical Sampling Protocols

Metals Levels

Four sampling protocols were used to determine metals leaching from the pipe loops: 1) stagnation samples from the metal pipe loop sections, 2) flowing samples from the recirculating reservoirs, 3) standing samples from the recirculating reservoirs, and 4) standing, acidified samples from the recirculating reservoirs. Each of these protocols is described in more detail below. Grab samples collected for lead concentrations were acidified (100 µL concentrated nitric acid in 15 mL of sample) with nitric acid and shipped to VT for analysis. The samples were measured for lead and other metals using ICP-MS in accordance with Standard Method 3125.

Stagnation Samples from the Metal Pipe Loop Sections. Grab samples were collected directly from the metal pipe loop sections at the end of the stagnation period, with the exception of Test 1 when samples were collected during continuous flow conditions. Prior to sampling, while the pumps were off, the inflow and outflow flexible tubing was pinched closed using surgical clamps. The pipe sections were tilted slightly up towards the outflow port (outflow slightly higher) so when the silicone stopper in the end of the influent pipe cap assembly was removed, water could flow passively into a collection beaker. The entire volume of water in the pipe was collected. Subsamples from the beaker were poured into 15-ml sample vials, and the remaining sample was returned to the 20-L reservoir.

Samples were collected after the specified stagnation period for each test and analyzed for total lead levels. Stagnation samples were collected at three different times during the testing sequence:

a) After the final stagnation period each week, prior to the water change (final weekly stagnation sample). Metals level results from these samples represent the lead release measured from the final stagnation period for the week. These samples were collected for Tests 1 through 6.
b) After the first stagnation period following a water change (initial stagnation sample). These samples were collected during Tests 4, 5, and 6. Metals level results from these samples represent lead release from the first stagnation period after the water was changed.
c) After the second and subsequent stagnation periods for each week (intermediate stagnation samples), but before the final stagnation sample for the week. These samples were collected during Tests 4, 5, and 6. Results from these samples indicate how lead release after stagnation changed over the course of the week, between the initial stagnation sample and the final weekly stagnation sample. These intermediate stagnation samples were collected for Tests 4, 5, and 6.

Flowing Reservoir Samples. Grab samples were collected from the recirculating reservoirs during flowing water conditions to determine lead levels in the recirculated water and to compare results to lead levels measured from standing reservoir samples (described below) to evaluate the occurrence of particulate lead in the re-circulating pipe loop apparatus.

Mixed Reservoir Samples. Grab samples were collected from the recirculating reservoirs during non-flowing conditions and prior to the water change. These samples were collected at

the end of Tests 3, 4, 5, and 6, and in the middle of Test 4. Each reservoir was disconnected from the loop, the contents were thoroughly mixed, and a grab sample was collected directly from the reservoir.

Standing Acidified Reservoir Samples. At the end of Tests 4, 5, and 6, the reservoirs for each pipe loop were disconnected and acid cleaned with a 2% nitric acid solution. Prior to collecting the sample, the contents of the reservoirs were stirred to suspend any particulate matter that may have settled to the bottom of the reservoir. Samples of the acidified contents were analyzed for total lead to evaluate the potential for adsorption of lead onto the Nalgene containers that were used for the recirculating reservoirs for each loop.

Electric Current and Potential Measurements

An ammeter was used to measure voltage and current between adjoining dissimilar metals in Loops 3 through 6, and between adjoining similar metals in Loop 7 to evaluate changes in these measurements under different testing conditions. These measurements were taken using a RadioShack 46-Range Digital Multimeter (#22-812) with an electrode attached (with a non-metallic spring clamp) to the exterior surface of the pipe materials. Measurements were made along the surface of the pipe and were collected a minimum of once a week at the end of a stagnation period.

RESULTS AND DISCUSSION

Sorption of Lead on Reservoirs

Concern about the impact of sorption of lead onto the Nalgene containers used for the recirculating reservoirs in this study might have on interpretation of lead release results prompted the acid cleaning and subsequent collection of acidified water samples from each of the reservoirs at the end of Tests 4, 5, and 6. Lead sorption was determined by evaluating lead levels measured from pipe loop reservoir samples before and after acidification at the end of Tests 4, 5, and 6 (Figure 11.9). In addition, a determination of particulate lead accumulation in the reservoirs was completed by evaluating lead levels from flowing reservoir samples, mixed reservoir samples and acidified reservoir samples (Figure 11.9).

The flowing and mixed reservoir samples had similar lead levels, indicating that either there were minimal amounts of particulate lead present, or they were not captured in the sampling protocol. However, high lead levels were measured from the acidified reservoirs at the end of Test 4, indicating that lead had been adsorbed and accumulated onto the plastic container walls throughout the course of the pipe loop study (Tests 1 through 4), and/or there may have been particulate lead present in the reservoirs that was solubilized upon acidification. This loss of lead in the recirculating loops may or may not have altered the trends seen in the lead levels measured under different water quality conditions. However, the rate of uptake and release of lead from the material used in the Nalgene reservoirs (fluorinated polyethylene) is unknown, as is the presence of particulate lead, so these phenomena confounded the interpretation of lead release data from the pipe loops, particularly for Test 3 and 4 water quality conditions.

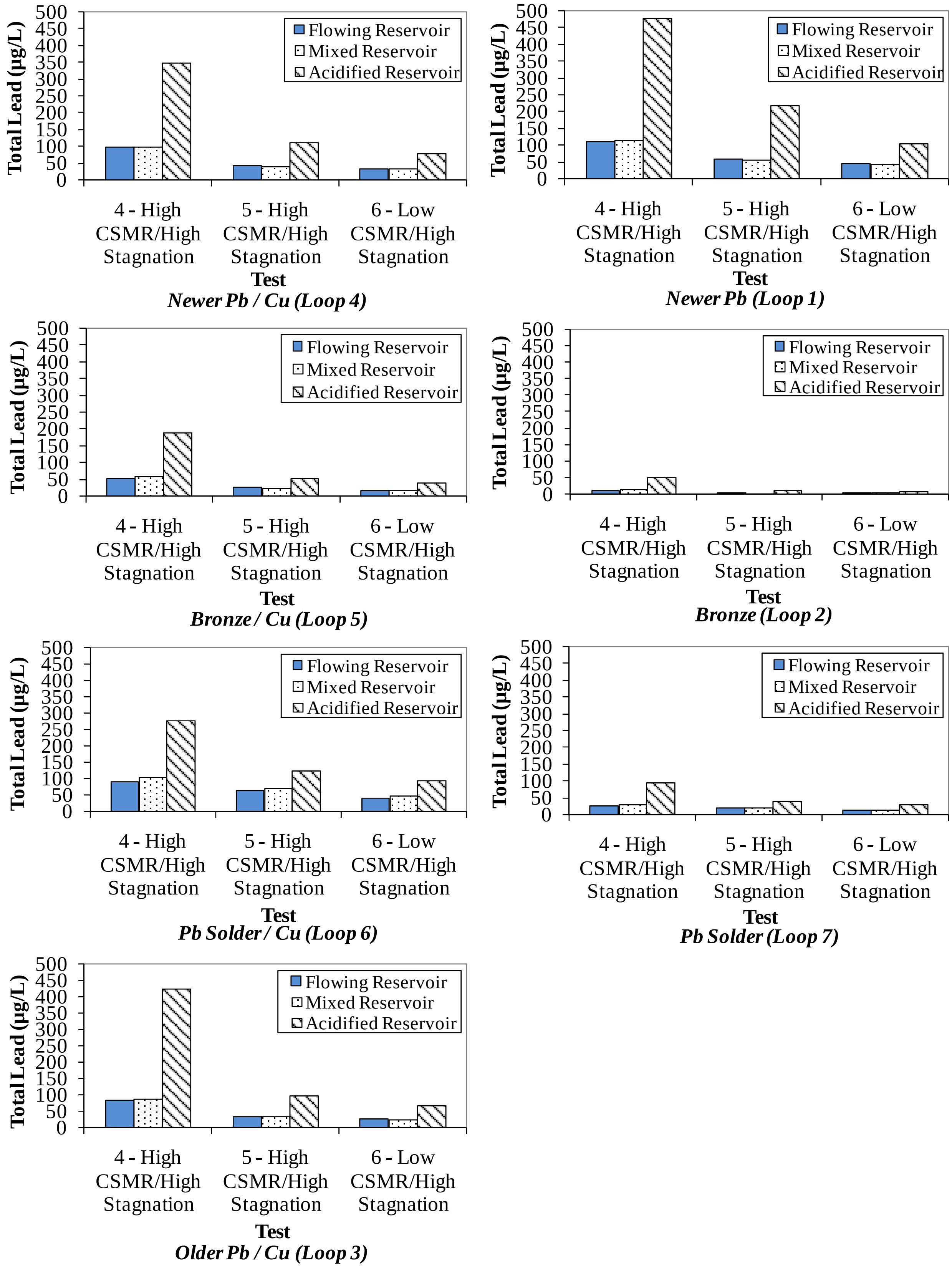


Figure 11.9 Total Lead Levels Measured in Flowing, Mixed, and Acidified Reservoirs

Figure 11.10 displays the results of total and dissolved lead levels measured on mixed reservoir samples during Tests 5 and 6 for each pipe loop. Loop 6 (simulated lead solder and new copper pipe) had the biggest differences between total and dissolved lead measurements (i.e. higher percentages of particulate lead) when compared to the other loops, indicating the presence of particulate lead. In general, dissolved lead ranged from 38% to 89% of the total lead measured from these mixed reservoir samples.

Galvanic Current

Effect of CSMR

The galvanic current measurements are not impacted by issues related to metal sorption in the reservoir. The galvanic current was measured at the end of the stagnation period in the recirculating pipe loops. Throughout the testing period, the high CSMR water had higher currents, or higher galvanic activity, than low CSMR water (Figure 11.11). Based on this study, the high CSMR conditions had an average of two times higher galvanic corrosion of lead than the low CSMR conditions for each of the pipe materials evaluated in this study (p-value < 0.01). In this study, the notation of positive current indicates that the lead material was being sacrificed.

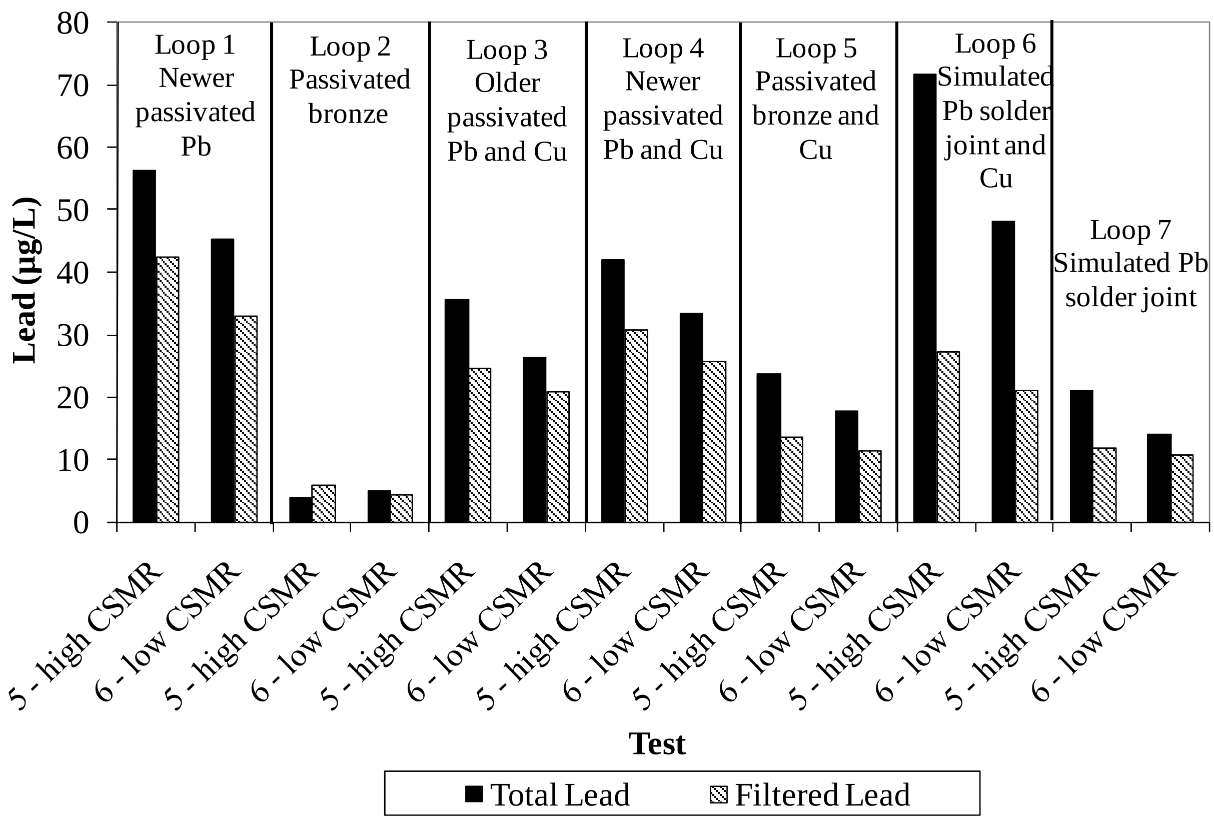


Figure 11.10 Total and Filtered Lead from Mixed Reservoir Samples in the Last Two Testing Sequences

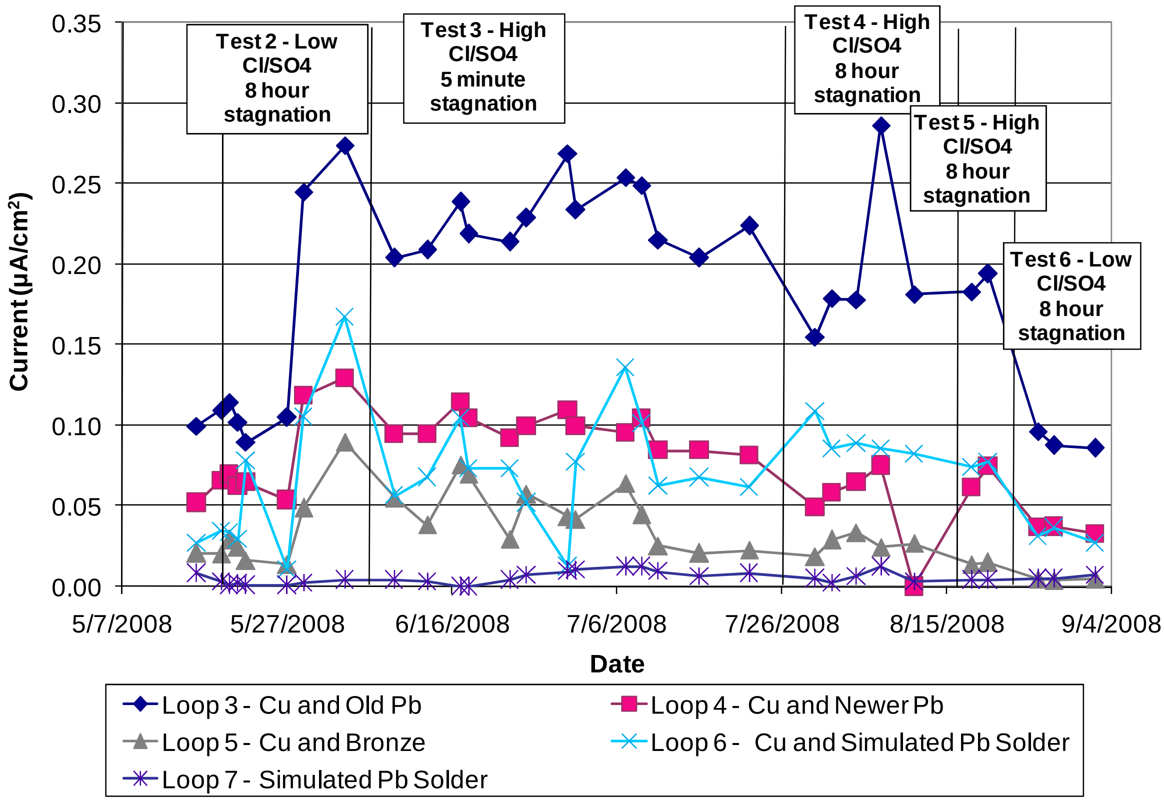


Figure 11.11 Current Density for the Dual Metal Loops as a Function of Time

The magnitude of the current was impacted by the flow frequency to a small extent (i.e., stagnation times). For example, for the high CSMR water tests, the magnitudes of the currents were similar between the period with only 5-minute stagnation and the period with 8 hours of stagnation (Figure 11.11). The galvanic currents were measured at the end of water stagnation periods.

Comparison of Lead Materials

The loop where copper and older passivated lead was connected exhibited the highest current densities at the 99% confidence level based on paired t-testing (Figure 11.12). The loops with the next highest currents from high to low were newer passivated lead connected to copper, simulated lead solder and copper, and passivated bronze and copper. Each loop was significantly different from the other loops, with the exception of the newer lead connected to copper and the simulated lead solder connected to copper. Those two loops had similar current densities throughout the study.

Contrary to expectations, the highest currents measured (or greatest galvanic corrosion activity) in this study were for the copper pipes coupled with old lead pipes (Figures 11.11 and 11.12). It was previously believed that the passivated or old lead pipes would have an established scale layer that would protect the lead from corrosion. The cause for this discrepancy is not understood. It is deemed possible that the passivating layer, which formed on the newer lead pipe surfaces in the 1+ year of exposure in the prior study using these samples, was more protective than the scale on the pipe surfaces that had not been cleaned.

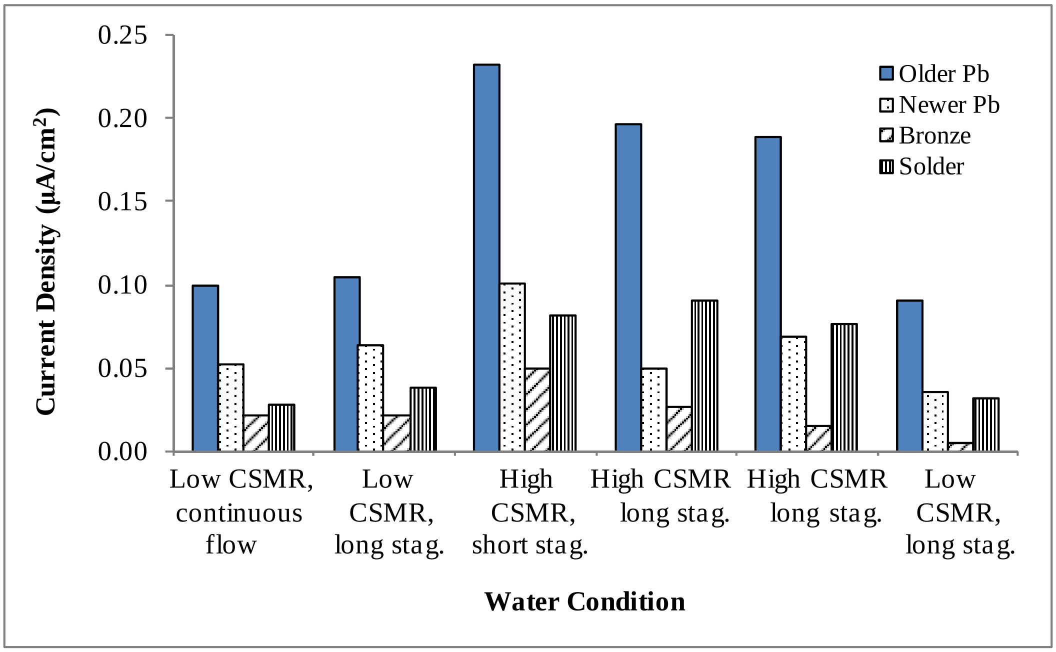


Figure 11.12 Average current density for each test and dual metal loop.

When connected with an external wire to simulate what occurs when the two metals are connected, a strong current was detected. A fairly high corrosion rate for lead in potable water would be 0.1 µA/cm^2. The acceleration of lead corrosion due to the galvanic current between the older passivated lead and copper was on the order of 0.2 µA/cm^2 in the water with high CSMR and less than 0.1 µA/cm^2 in low CSMR water. Thus, the galvanic current between the copper pipe and the lead pipe is quite significant.

Lead Release from Stagnant Pipes

Effect of CSMR

To compare lead release among the loops, lead concentrations measured from the final weekly stagnation sample collected for each loop for Tests 5 (high CSMR) and 6 (low CSMR) were normalized by calculating the total mass of lead released per lead material surface area. To obtain these values, the lead concentrations were divided by the volume of water exposed to the pipes and divided by the surface area of the lead material. Table 11.6 displays the surface area of lead in contact with water for each loop that contained lead bearing material (lead pipe, bronze pipe, simulated lead solder). Loops 1, 3, and 4 had the same surface area of exposed lead, as all three loops incorporated a 12” length of lead pipe. Loops 2 and 5 had the same exposed surface area based on the 12” length of bronze pipe, which had a slightly smaller inner diameter than the lead pipe. Loops 6 and 7 had a much smaller area of lead exposed, as both loops incorporated two – 3” lengths of copper pipe that had been dipped in lead solder to simulate a lead solder joint.

The calculated mass of lead released per lead surface area after 8 hours of stagnation may be elevated because the samples were collected at the end of the week. By the end of the week, lead had already been released from the plumbing materials into the water and was being

recirculated throughout the week. However, the values provide a rough estimate of the impacts of stagnation, CSMR, galvanic connection, and plumbing material on lead leaching.

Higher CSMR appeared to exacerbate lead leaching from galvanic connections of newer lead, bronze, and lead solder to copper pipe (Figure 11.13). Additionally, lead solder with no connection to copper had elevated levels of lead in high CSMR water. Based on the current density data in Figure 11.12, high CSMR water would be expected to increase lead release for the passivated lead pipe compared to low CSMR water. However, the lead release data from the stagnant pipes did not confirm this effect.

Effect of Galvanic Connection to Copper Pipe

Additionally, in all cases, the galvanic connection of the lead pipe material to copper increased lead leaching compared to when there was no connection to copper (Figure 11.13). For example, galvanic corrosion of lead more than tripled from approximately 0.06 µg/cm^2 to 0.22 µg/cm^2 when newer lead pipe was connected to copper pipe for high CSMR water. Similar results were observed for low CSMR for newer passivated lead, but the increase was slightly lower at 1.5 times higher with the galvanic connection. When bronze pipe was connected to copper pipe, lead release increased between 6 and 30 times for low and high CSMR waters, respectively. Similarly, simulated lead solder connected to copper increased lead leaching approximately 7 times compared to simulated lead solder alone.

Table 11.6
Surface Area of Exposed Lead Bearing Material and Water Volume for Each Loop

Pipe Loop Designation	Pipe Material	Surface Area of Lead Bearing Material Exposed (cm^2)	Volume of Water Exposed to Pipes (mL)
1	Newer passivated lead pipe	201.0	87
2	Passivated bronze pipe	172.3	80
3	Older passivated lead pipe/ Copper pipe	201.0	348
4	Newer passivated lead pipe/ Copper pipe	201.0	348
5	Passivated bronze pipe/ Copper pipe	172.3	341
6	Simulated lead solder joints/ Copper pipe	95.7	304
7	Simulated lead solder joints	95.7	43

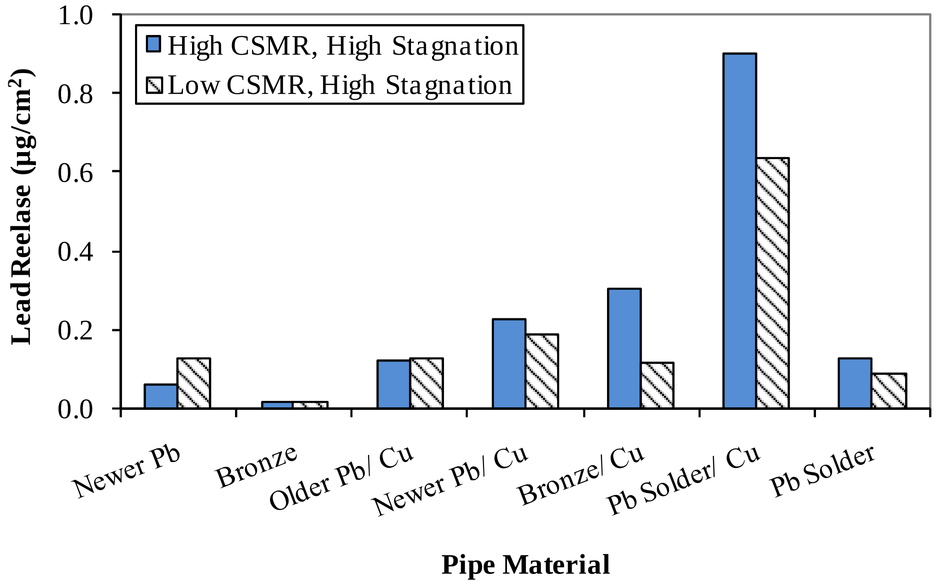


Figure 11.13 Mass of lead released per surface area of lead material in low and high CSMR waters

Lead Levels in Acidified Reservoirs

Effect of CSMR

Results obtained for Tests 5 and 6 may represent the best comparison of lead levels and lead release from the various lead bearing materials under high and low CSMR conditions, since the acid cleaning of the reservoirs prior to the start of each of these tests allowed for an equivalent baseline starting point with respect to lead levels. High CSMR water was more aggressive than low CSMR water at the 95% confidence level, based on grouping all data into low and high CSMR (Figure 11.14). The increase in lead release due to CSMR is consistent with the galvanic current data; however, the magnitude increase in the lead levels was not as high as would be expected based on the galvanic current data. It is possible that lead particulate release and build-up or breakdown of the mass of lead in the existing scale on the reservoir, even with low CSMR water, contributes to the discrepancies between the lead levels and the galvanic currents.

Comparison of Galvanic Connection and Lead Materials

Comparing lead release per unit surface area for each lead bearing material for Tests 5 and 6, the newer passivated lead with no copper loop and the simulated solder connected to copper loop had the highest lead levels for both high and low CSMR waters (Figure 11.14). Contrary to expectations, the connection of copper pipe to the newer lead pipe decreased lead released to the water. It was deemed hypothetically possible that the connection of the lead pipe to copper could help stabilize pre-existing Pb(IV) scale on this pipe sample. Alternatively, recent work has shown that after longer-term exposure lead leaching data begins to agree with expectations based on trends in galvanic current (Nguyen et al. 2009). Additional work on this issue is needed.

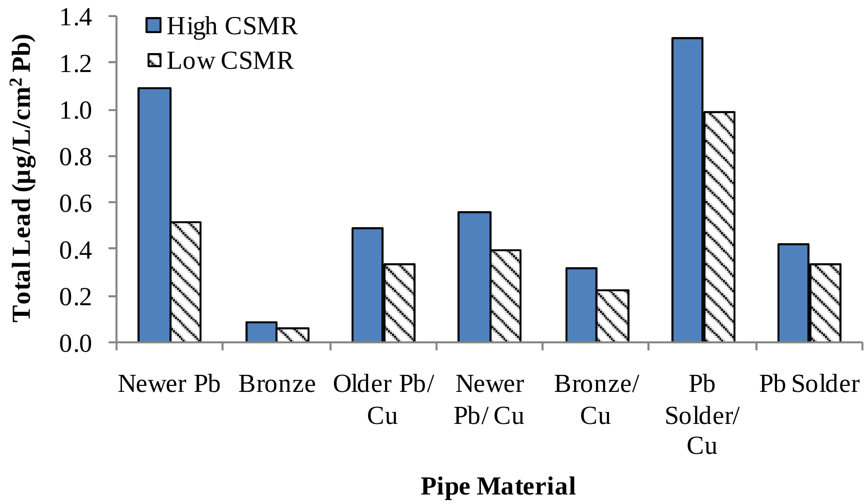


Figure 11.14 Total lead released per lead material surface area in acidified reservoirs in Tests 5 (high CSMR water) and 6 (low CSMR water)

Consistent with theory, higher lead release was observed for bronze pipe connected to copper and solder connected to copper compared to the single metal loops for each metal. For example, connecting bronze pipe to copper pipe increased the lead in water by approximately 4 times for both CSMR levels. In high CSMR water, the lead release was increased from 0.08 to 0.32 µg/L/cm^2, while the lead release increased from 0.06 to 0.23 µg/L/cm^2 in low CSMR water. Similarly, the lead leaching was increased by 3 times for the simulated solder connected to copper compared to simulated lead solder alone, increasing lead release from 0.42 to 1.3 µg/L/cm^2 in high CSMR water and from 0.34 and 0.99 µg/L/cm^{2}in low CSMR water.

CONCLUSIONS

Summary of Pipe Loop Testing Materials and Methods

- A pipe loop testing apparatus was developed to examine the effects of changing chloride to sulfate mass ratio (CSMR) on lead release from lead and bronze materials.
- The pipe loop testing apparatus was designed to test components in a "single-metal" and a "dual metal" (Figure 11.1) pipe loop configuration. In both configurations, the apparatus was operated in a re-circulating mode. The "dual metal" pipe loop configurations for Loops 3 through 6 were designed to provide ~three times the surface area of copper to lead bearing material.
- Three testing methods were integrated into the pipe loop apparatus to meet the testing objectives: (1) evaluation of lead release from various lead source materials under different CSMRs, (2) measurement of pH levels of water in the pipe sections, in the vicinity of the dissimilar pipe juncture to determine if there were any pH gradients in the vicinity of the connection between dissimilar metals, and if so, if the gradient was impacted by different CSMR conditions, and (3) measurement of current and voltage between dissimilar pipe sections to determine if these measurements were impacted by different CSMR conditions. Lead concentrations were measured by collecting

grab samples 1) of water that had been allowed to stagnate in the metal pipe sections (stagnation samples from loops) and 2) of water from the re-circulating reservoirs.

- The pipe loop testing apparatus was assembled and operated at the HDR ARTC testing facility in Redmond, Wash. Tap water supplied to the ARTC testing facility was adjusted to pH 7.0-7.5 and phosphate of 1.0 mg/L. These conditions were selected to represent typical water quality conditions for use of phosphate for corrosion control. The chloride sulfate mass ratio of the water was altered for the various test conditions from ~2.0 (low) to ~10 (high by addition of NaCl in an effort to maintain the target chloride to sulfate ratio for each batch of water).
- For the final two test sequences (Test 5 and Test 6), the reservoirs were acid washed in order to assess the potential for sorption of lead onto the Nalgene reservoirs.

Effects of CSMR and Galvanic Connection on Lead Release

- Higher CSMR increased galvanic corrosion of lead:copper couples in dual metal loops.
- Connection of lead plumbing materials to copper pipe generally increased lead leaching, based on lead levels in stagnant pipes for most materials tested.
- Based on the acidified reservoir data, the connection of newer lead pipe to copper reduced the lead in water, compared to newer lead pipe not connected to copper.
- The current density data indicated that the corrosion rate for older lead pipe connected to copper was the highest of all the loops.
- The simulated lead solder/copper loop consistently had the greatest lead release under high CSMR. Even though the galvanic currents for the simulated solder were not the highest in this study, the release of particulate lead from the solder may explain the discrepancy between current and lead data.
- Simulated lead solder joints connected to copper pipe exhibited the largest difference between total and dissolved lead concentrations measured from the re-circulating reservoirs after the water had been mixed, indicating a higher percentage of particulate lead may have been released from this lead bearing material when compared to newer or older passivated lead pipe and bronze pipe.

Sorption of Lead and Occurrence of Particulate Lead

- Sorption of lead onto the material used for the re-circulating reservoirs was demonstrated by measuring lead levels from samples collected from the reservoirs after acidification. This sorption may or may not have altered trends seen in lead levels under different CSMRs.
- Lead release was lower during high CSMR and longer stagnation periods (8 hrs) (Test 4) when compared to high CSMR and short stagnation periods (Test 3), indicating that perhaps more lead was lost to sorption onto the Nalgene containers and/or other non-metals components of the pipe loops during the longer stagnation period during Test 4, and/or the rate of lead release was lower during this test. Alternatively, there may have been inherent variability in the lead data and/or the

impacts of sorption onto the Nalgene containers which would make it difficult to distinguish differences in lead release between the loops for these two test conditions.

- High levels of particulate lead did not occur during the study, with the exception of the simulated lead solder material. More particulate lead may be released from lead solder used to join copper pipes than from passivated lead pipes.

Recommendations for Future Research

This study provided initial evaluations of changes in CSMR on lead release from several different lead bearing materials. To expand on the results obtained, several issues have been identified that should be explored further:

- More research is needed to examine the inter-relationships of other water qualities (e.g., different pH, alkalinity, chlorine/chloramine, with and without phosphate, etc.) and the effects of changes in CSMR.
- The loop experiments carried out in this study involved relatively short periods of exposure to the different CSMR conditions. It may be appropriate to carry out these types of experiments under much longer periods of exposures to each water quality condition.
- More research is necessary to determine changes in interior scales formed under different CSMR conditions, and the characteristics of those scales with respect to lead uptake and release.
- An evaluation of the most appropriate materials to be used in dump and fill, re-circulating, and flow through experiments designed to assess lead release should be completed. Results from this study indicated that appreciable sorption onto the fluorinated polyethylene material used in the re-circulating reservoirs occurred, and clouded the interpretation of the data collected. In this study, results from Tests 5 and 6 were more reliable than results from Tests 1 through 4. An understanding of which materials are least likely to sorb lead and/or development of operations and sampling protocols to minimize the impact of this phenomenon should be explored.
- On the basis of these results, clear conclusions about the effects of Pb:Cu galvanic connections on leaching of lead from pure lead pipe are not possible. Additional research is needed to clarify this issue.

APPENDIX A
PICTURES FROM FAILED SOLDER IN UTILITY I STUDY

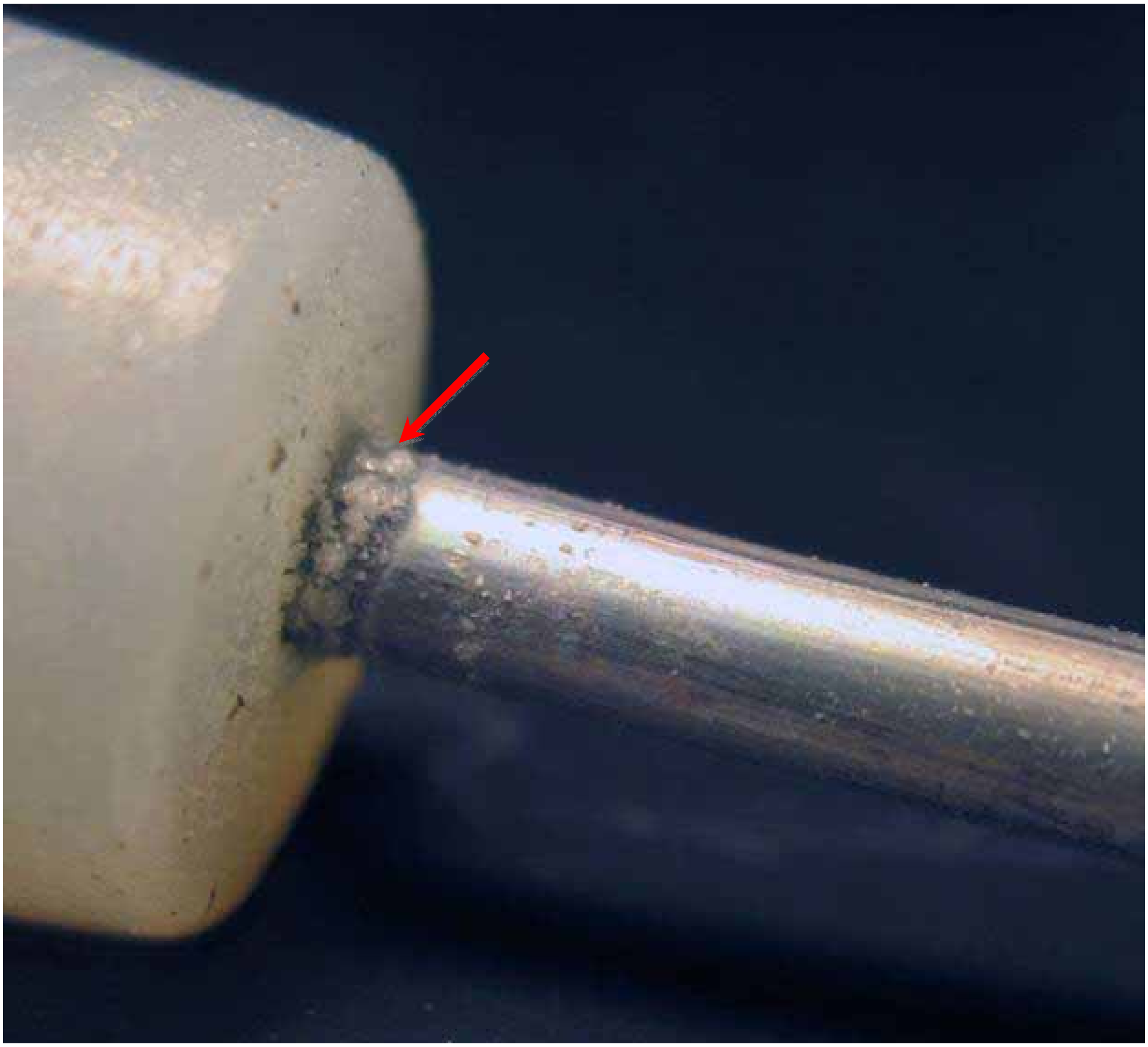
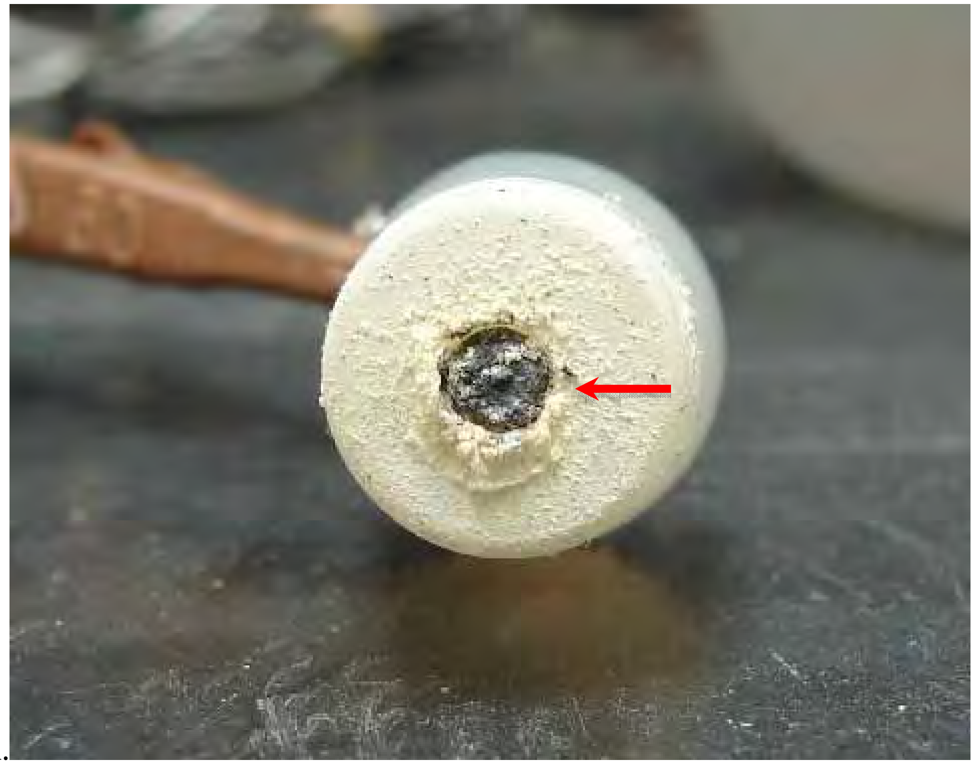


Figure A.1 Site of corrosive attack at silicone stopper/solder interface. The visual attack was not atypical for all of the water conditions. The solder pictured here was exposed to alum-treated water with chloramine.



a.

b.

Figure A.2 Top (a) and side (b) views of the solder that failed at the end of the experiment. The solder was exposed to alum-treated water with free chlorine and high alkalinity. Despite the solder failure, the water condition was the least aggressive in terms of lead release. Due to variability in corrosion, triplicates were used. The red arrows indicate the location of the solder failure.

APPENDIX B
OPERATIONAL AND FIELD WATER QUALITY PARAMETER MEASUREMENTS

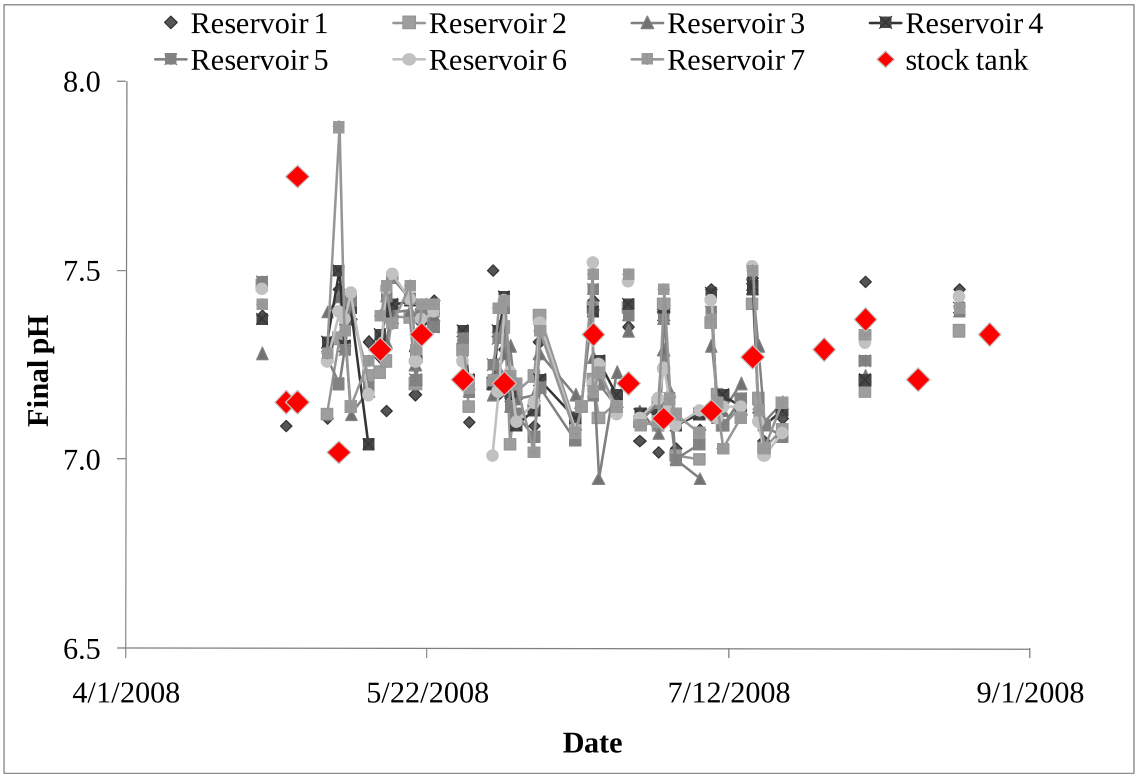


Figure B.1 pH as a function of time for Utility H pipe loop study.

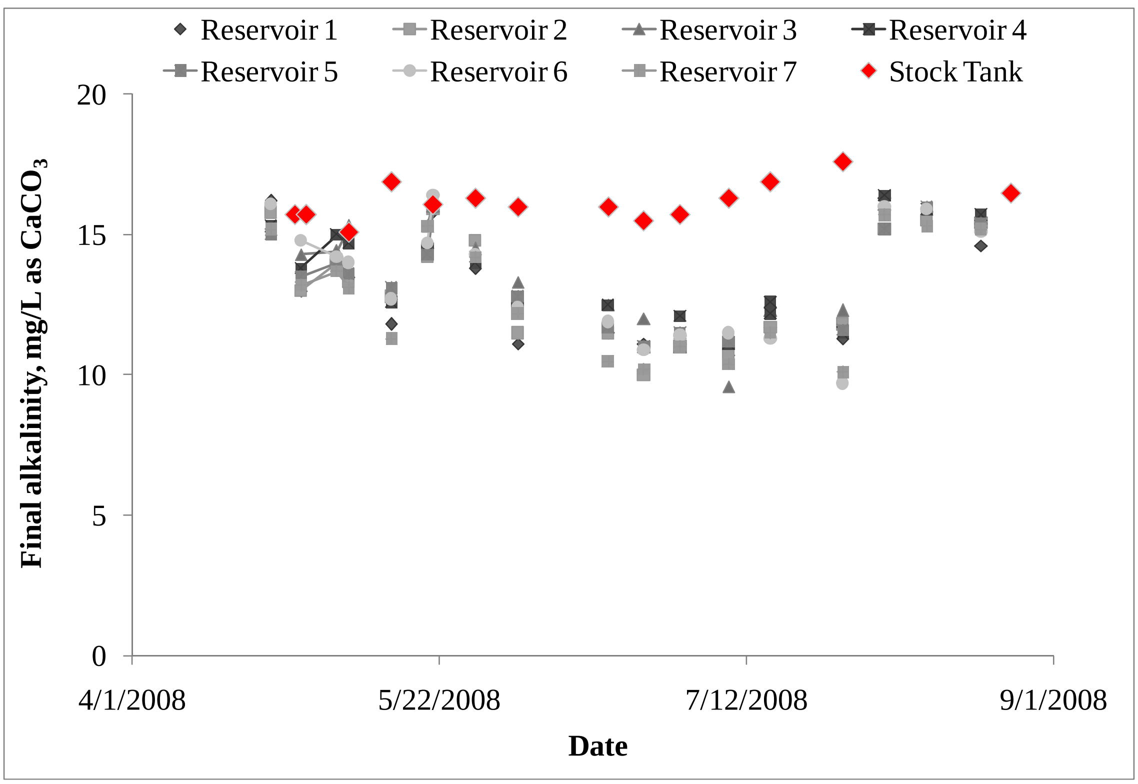


Figure B.2 Alkalinity of water over time for Utility H pipe loop study.

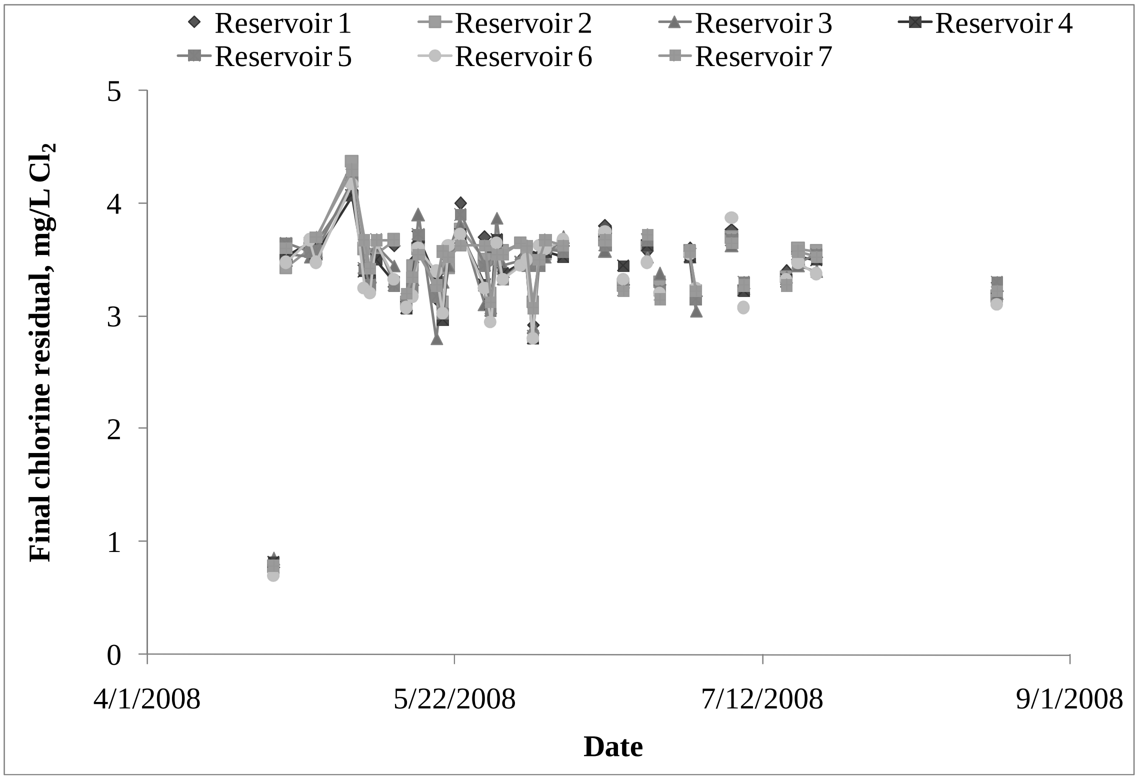


Figure B.3 Total chlorine residual as a function of time for Utility H pipe loop.

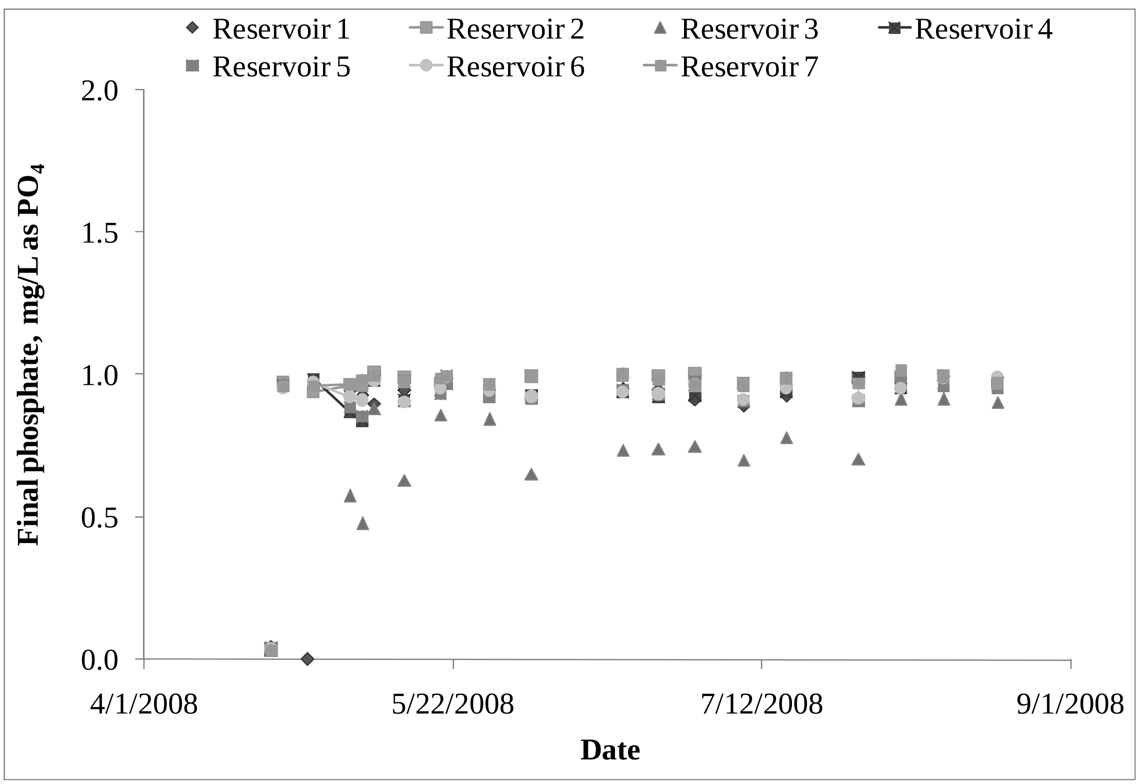


Figure B.4 Chloride-to-sulfate mass ratio of the water in Utility H case study.

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ABBREVIATIONS

°C	degrees Celsius
d	day
EPA	United States Environmental Protection Agency
°F	degrees Fahrenheit
gpm	gallons per minute
ICP-MS	inductively coupled plasma - mass spectrometry
in	inch
L	liter
m	meter
M	molar
mg	milligram
mg/L	milligram per liter
mL	milliliter
mm	millimeter
mM	millimolar
mo	month
µA	micro-amps
$\mu A/cm^2$	micro-amps per squared centimeters
MCL	Maximum Contaminant Level
N	Newton
NOM	natural organic matter
PAC	Project Advisory Committee
pp.	pages
ppb	parts per billion
ppm	parts per million
PVC	polyvinyl chloride
rpm	revolutions per minute
s	second
TOC	total organic carbon

wk	week
WQTC	Water Quality Technology Conference
yr	year

Impact of Chloride: Sulfate Mass Ratio (CSMR) Changes on Lead Leaching in Potable Water

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EXHIBIT I

From: Michael Glasgow <mglasgow@cityofflint.com>
Sent: Thursday, October 31, 2013 11:02 AM
To: Daugherty Johnson
Subject: Re: Distribution system nifo

Yes, mg/L. On average Detroit water is around 100 mg/L, for us softening we will do good to get around 130 mg/L.

On Thu, Oct 31, 2013 at 10:59 AM, Daugherty Johnson <djohnson@cityofflint.com> wrote:
Thanks Mike. What value is hardness measured in? mg/l?

On Thu, Oct 31, 2013 at 10:37 AM, Michael Glasgow <mglasgow@cityofflint.com> wrote:
Duffy,

Sorry I missed your call yesterday, I was off on annual. About your inquiry of the effect of treated flint river water or the distribution system, I have heard different arguments. Personally, I don't believe it will have much effect. It all depends on our final water quality (mostly pH & alkalinity). Most likely we will have a scale-forming water, and this may lead to lots of scale build up in the system. This may cause reduced flow in piping that is already "partially clogged" ultimately affecting pressures, and could increase some maintenance on pump stations if the scale build up starts to occur in the pumps. As we operate the plant we will have to develop some goal for what type of finished water quality we wish to have. The best case is to keep the parameters (pH, alkalinity, & hardness mainly) as close as we can to Detroit water to have a minimal effect on the distribution system. At times the process will determine what we "can" do.

Mike Glasgow

EXHIBIT J

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
LANSING DISTRICT OFFICE

DAN WYANT
DIRECTOR

September 10, 2014

Mr. Brent Wright
City of Flint Water Treatment Plant
4500 North Dort Highway
Flint, Michigan 48505

SUBJECT: Compliance Communication
Total Trihalomethane Operational Evaluation Requested

Under the Stage 2 Disinfectants and Disinfection Byproduct Rule, the City of Flint has been required to collect samples for the analysis of Total Trihalomethane (TTHM) and Haloacetic Acids (HAA5) at eight sites within the City's water distribution system. The City has completed two quarterly monitoring periods since changing its source water to the Flint River effective April 25, 2014.

Normally an Operational Evaluation Level (OEL) would be calculated in accordance with the Michigan Safe Drinking Water Act, Public Act 399, 1976, as amended, Administrative Rule 7196 (R 325.107196), each quarter once three quarters of results have been obtained and compared with the respective maximum contaminant level (MCL) for TTHM. Normally the calculation would be made as follows:

(2 x current quarter + sum of 2 previous quarters) divided by 4

As the City of Flint currently has only two quarters of data, the calculation has been modified as follows:

(2 x current quarter + previous quarter) divided by 4

The resulting OEL for each site is listed in the table below. All results are in parts per billion (ppb):

	TTHM			HAA5		
	5/21/14	8/21/14	Mod. OEL	5/21/14	8/21/14	Mod. OEL
DBP1 McDonalds 3719 Davison	162.4	145.3	113	64	43	38
DBP2 Liquor Palace 822 S. Dort Highway	111.6	112	84	52	40	33
DBP3 North Flint Auto 3302 S. Dort Highway	96.5	127.2	88	48	31	28
DBP4 University Market 3606 Corunna	106.4	181.3	117	55	24	26
DBP5 B&P Gas Station 2501 Flushing	75.1	196.2	117	38	17	18
DBP6 Salem Housing 3216 MLK Boulevard	82.2	112.4	77	41	25	23
DBP7 Kroger 5018 Clio Road	88.2	144.4	94	49	30	27
DBP8 Taco Bell 6204 N. Saginaw	79.2	118.3	79	50	37	31

As shown in the table above, even with this less restrictive modified method, six of the City's eight sites already exceed the OEL limit of 80 ppb for TTHM. In addition, the City's two other sites are both more than 95% of the TTHM OEL limit.

The MCL for TTHM and HAA5 is based on a locational running annual average for each site, essentially the average at each site over the four previous quarterly monitoring periods. However, with TTHM levels of this magnitude, it is likely the MCL will be exceeded for at least one of these eight sites from just three quarters of monitoring results. For TTHM, four quarters at the MCL of 80 ppb (4 x 80) would provide 320 ppb allowable. As an example, site DBP1 through just two quarterly monitoring periods has a total of 307 ppb (162+145), leaving only 13 ppb over two more quarterly monitoring periods to maintain compliance with the MCL.

Therefore, this office is requesting the City of Flint complete an Operational Evaluation in accordance with Administrative Rule 719l (R325.10179l). The Operational Evaluation Report shall be submitted to this office no later than November 28, 2014. The report shall not be limited in scope and shall include the following:

Examination of Treatment Operational Practices
- Changes in source water quality
- Treatment changes
- Storage tank operations
- Excess storage capacity
- Treatment problems that contribute to TTHM formation

Examination of Distribution Operational Practices
- Storage tank operations
- Excess storage capacity
- Distribution system flushing

The report shall also include steps the City could consider to minimize future exceedances.

Additional guidance on completing the Operational Evaluation Report, including a number of forms that can be used to gather and evaluate water system information is provided in the United States Environmental Protection Agency's (U.S. EPA) Operational Evaluation Guidance Manual. This document is available on the U.S. EPA's website at the following link:

http://www.epa.gov/ogwdw/disinfection/stage2/pdfs/draft_guide_stage2_operationalevaluation.pdf

Be advised, failure to submit an Operational Evaluation Report by this deadline is a reporting violation subject to Tier 3 Public Notification.

The OEL is an indicator of operational performance. The water system must take proactive steps to be able to comply with the MCL's for TTHM and HAA5. While it is recognized that removal of Total Organic Carbon disinfection byproduct precursors as part of the treatment process has performed above minimum removal requirements under the treatment technique, around 4 parts per million of organic carbon are still present in the treated water and may be leading to additional TTHM formation in the City's distribution system.

While health effects associated with disinfection byproducts contaminants are based on chronic exposure, the City has available alternatives that must be considered to achieve compliance with this drinking water public health standard.

If you have any questions regarding this information, please contact me at the number below.

Sincerely,

Michael Prysby

Michael Prysby, P.E.
District Engineer
Office of Drinking Water and
Municipal Assistance
Lansing District Office
(517) 290-8817

cc: Mr. Darnell Early, City of Flint
Mr. Daugherty Johnson III, City of FLint
Mr. Howard Croft, City of Flint
Mr. Robert Bincsik, City of Flint
Ms. Liane Shekter Smith, P.E., DEQ
Mr. Richard Benzie, P.E., DEQ
Mr. Stephen Busch, P.E., DEQ
Genesee Co. Health Dept.

EXHIBIT K

Michigan

General Motors shutting off Flint River water at engine plant over corrosion worries

By **Ron Fonger | rfonger1@mlive.com**
on October 13, 2014 at 6:00 PM, updated January 17, 2015 at 10:48 AM

FLINT, MI -- Chloride levels in treated Flint River water are so high that General Motors will no longer use it at its engine plant here because of fears it will cause corrosion.

GM spokesman Tom Wickham said Monday, Oct. 13, that the company has reached a temporary agreement to buy Lake Huron water from Flint Township for Flint Engine Operations on West Bristol Road.

Under the agreement, the plant will return as a Flint water customer after the city switches back to using Lake Huron water -- after the Karegnondi Water Authority pipeline is completed -- something that's not expected to happen until the end of 2016.

"Because of all the metal ... you don't want the higher chloride water (to result in) corrosion," Wickham said. "We noticed it some time ago (and) the discussions have been going on for some time."

The city began using the Flint River as its source of public water in April, ending five decades of buying pre-treated Lake Huron water from the city of Detroit.

The switch has been rocky.

Residents have complained to the City Council about the smell and taste of the river water, the city's Water Treatment Plant has struggled to maintain residual chlorine levels throughout the system, and there were three boil water advisories in a 22-day span this summer after positive tests for total coliform and fecal coliform bacteria.

The Flint Journal could not immediately reach Howard Croft, Flint's Department of Public Works director, for comment on the switch by GM, which uses an average of about 75,000 gallons of water daily at the engine plant.

Mike Prysby, district engineer for the Michigan Department of Environmental Quality, said the level of chloride in treated Flint River water is easily within public health guidelines.

Tests have shown Flint's water in the range of 50 to 60 milligrams of chloride per liter, higher than the level considered excellent, which is less than 20 milligrams per liter, but lower than the level that's considered objectionable, which is higher than 250 millirams per liter.

FLINT WATER

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All Stories

The city uses ferric chloride, which works as a coagulant, in river water to help remove suspended and dissolved solids and contaminants, according to Prysby.

Flint Township Supervisor Karyn Miller said GM will have to complete work to tie into the township's water distribution system before it can it can start to take in Lake Huron water again.

"It's going to happen as soon as they can (make the connection)," said Miller, who said the township Board of Trustees agreed last week to let the automaker plug into its water network.

"We've already worked something out with GM and GM has worked something out with the city," she said.

Wickham said GM has been coping with the water issue at Flint Engine by further treating the water it receives from Flint and supplementing it with non-river water.

He said no other GM plants in Flint are switching to use a different source of water at this time.

The company operates a stamping plant and truck assembly plant in the same vicinity as the engine plant -- on the southwest side of the city.

Genesee County Drain Commissioner Jeff Wright said his office certified that it has the capacity to supply the water GM needs at the engine plant and is working with the company to connect so that it can become a Flint Township water customer.

Cities and townships around the county make up the county water and sewer system and each bills businesses and residents for water and sewer services.

EXHIBIT L

LOCKWOOD, ANDREWS & NEWNAM, INC.
DRAFT

Operational Evaluation Report

City of Flint

Trihalomethane Formation Concern

November 2014

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

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EXECUTIVE SUMMARY

Environmental Protection Agency (EPA) and Michigan Department of Environmental Quality (MDEQ) regulations require that public water suppliers test drinking water quarterly throughout the distribution system for disinfectant by-products (DBP's). Two categories of DBP's, tri-halomethanes (THM) and halo-acetic acids (HAA5), are regulated and must be tested for. The City of Flint began operation of their water treatment plant (WTP) full time with the Flint River as the source on April 25, 2014. Since that time, two quarters of samples taken indicate that future violations are inevitable for total THM without some modifications to the water system. In response, the City hired Lockwood, Andrews & Newnam, Inc. (LAN) to complete this Operational Evaluation Report (OER) in conformance with EPA guidelines with the goal to determine the cause(s) of high levels of THM and evaluate possible solutions.

The EPA promulgated the Stage 2 Disinfectants and Disinfection By-Products Rule (DBPR) in January 2006 which set maximum contaminant levels (MCLs) for total trihalomethanes (TTHM) and HAA5 based on an annual running average, tested quarterly, for a given sampling location. The City of Flint reports levels from 8 sampling test locations. Of the two quarterly sampling cycles since Flint began operating the WTP full time, HAA5 levels have been acceptable but TTHM levels have been high at all 8 sampling sites.

According to the Stage 2 DBPR, the annual average value requires 3 quarters of sampling data with the most current period counting twice. Therefore, the City of Flint has not yet experienced a violation of the TTHM MCL because only 2 quarters of data have been obtained. However, levels recorded indicate the likelihood of an MCL exceedance later this year.

A number of issues have been identified as possibly contributing to the high THM levels measured.

1. Inefficient ozone system operation which has resulted in increased chlorine feed.
2. Sewer leak discovered upstream of intake causing high total Coliform levels, increased chlorine demand, and resulting need to increase chlorine feed.
3. Bypass stream around softening contributed to chlorine demand.
4. Unlined cast iron pipes in the distribution system contributing to chlorine demand.
5. Recirculating water in the distribution system due to less than ideal configuration of Cedar Street and West Side pump stations.
6. Broken valves resulting in stagnant water in some areas.
7. High chlorine demand in filters.
8. High THM formation potential (THMFP) in source water.
9. Less than optimal removal of THM precursors

ACTION PLAN

The City of Flint has signed an agreement with the Karegnondi Water Authority (KWA) to purchase raw water drawn from Lake Huron. The KWA system is currently under construction and expected to be operational by late 2016. The water supply from Lake Huron will have entirely different water quality characteristics from the Flint River and those characteristics are expected to yield drastically reduced DPB formation. With that, non-structural options to help reduce THM levels are much preferred over solutions requiring new construction. Therefore, two categories of actions have been devised: Stage 1 being actions that can be completed relatively quickly without major construction and Stage 2 consisting of either long term actions or solutions requiring major construction. The City has completed or intends to complete Stage 1 Actions by February 16, 2015, the week in which the next

quarterly sampling is to be done. Stage 2 actions are to be implemented only if Stage 1 actions are ineffective in adequately reducing TTHM levels and therefore Stage 2 is contingent upon the outcome of Stage 1.

Stage 1 – Immediate Actions

- Hire ozone system manufacturer to troubleshoot ozone system
- Bench scale jar testing
  - Match existing process and access possible areas of improvement
  - Simulate potential modifications to treatment process
  - Evaluate coagulation and flocculation polymer aid feeds to assist with TOC removal
- WTP operational changes
  - Discontinue softening bypass stream to reduce chlorine demand
  - Disinfection of filter beds to reduce chlorine demand
  - Possibly begin coagulation and flocculation polymer aid feeds to assist with TOC removal depending on bench scale test results
- Increase water main flushing efforts to minimize stagnant water
- Water system modeling to identify areas with high water age and potential solutions
  - Cedar Street Pump Station potential recirculation
  - West Side Pump Station potential recirculation
  - Storage tank volume use
  - Possible broken closed valve locations
  - Locations in need of flushing
  - Lower high water levels in storage tanks

Stage 2 – Contingent Actions

- Fix ozone system
- Start feeding coagulation and flocculation polymer aids to lower TOC, if not completed in Stage 1
- Convert to lime and soda ash softening
- Change disinfectant to chloramine or chlorine dioxide until KWA
- Install pre-oxidant feed at intake to optimize ozone disinfection
- Implement advanced treatment for THM precursor removal
- Increased main flushing based on water modeling results
- Continue valve replacements with water model assistance
- Emphasize cast iron pipes on water main replacement priority list

I. BACKGROUND

The City of Detroit Water and Sewer Department (DWSD) has historically provided drinking water for the City of Flint and Genesee County. In the late 1990's growing concern regarding the reliability of the DWSD supply prompted the City of Flint to upgrade their existing water treatment plant (WTP). Those improvements, defined as Phase I, were completed in 2005 and were intended to allow the Flint WTP to operate, using the Flint River as the source, for an extended period of time in the event that supply from the DWSD was temporarily interrupted. Additionally, the Phase I improvements set the stage for Flint to break free from dependence on the DWSD supply and water charges over which they had no control.

A. WATER SUPPLY TRANSITION

1. Detroit Water and Sewer Department (DWSD)

Until recently the Genesee County and Flint region had been provided drinking water by the DWSD. However, due to excessive cost increases and reliability issues with the DWSD system other options had to be explored.

2. Karegnondi Water Authority (KWA)

In 2010 the Karegnondi Water Authority (KWA) was formed for the purpose of developing a new water supply from Lake Huron to serve the region in lieu of the DWSD supply and the City of Flint elected to join. The KWA expects the new system which is currently being constructed to become operational in the fall of 2016.

3. Flint River – Interim Period

With a water supply agreement between Flint and the DWSD set to expire in early 2014 and the KWA system not expected to be operational until late 2016, the City of Flint decided to initiate operation of the existing WTP full time utilizing the Flint River as the interim water source. A variety of WTP improvements were necessary for the Flint plant to become a full time plant. For purposes of this report, Phase II improvements to the Flint WTP are improvements which have been made to allow the plant to operate full time with either the Flint River as the source or the KWA supply as the source.

B. TTHM PENDING VIOLATIONS

The calculation for determining if the MCL has been violated for TTHM is:

(2 x current quarter value + previous 2 quarter values) / 4

Flint has completed tests for 2 quarters and therefore has not violated an MCL limit to date. However, the third quarter of sample data is likely to provide MCL exceedances at all 8 sampling sites. Test results are tabulated below.

TABLE 1 – 2014 DBP TEST RESULTS							
Sample Location	TTHM				HAA5		
	1st Qrt 5/21/14	2nd Qrt 8/21/14	3rd Qrt		1st Qrt 5/21/14	2nd Qrt 8/21/14	3rd Qrt
3719 Davison - McDonalds	162.4	145.3			64	43	
822 S. Dort Hwy - BP Gas Sta.	111.6	112.0			52	40	
3302 S. Dort Hwy – Liquor Palace	96.5	127.2			48	31	
3606 Corunna – Taco Bell	106.4	181.3			55	24	
2501 Flushing – Univ. Market	75.1	196.2			38	17	
3216 MLK – Salem Housing	82.2	112.4			41	25	
5018 Clio – Rite Aid	88.2	144.4			49	30	
6204 N. Saginaw – N. Flint Auto	79.2	118.3			50	37	

TTHM MCL = 80 ug/l
HAA5 MCL = 60 ug/l

C. WATER TREATMENT PLANT RECENT IMPROVEMENTS & STATUS

1. Phase I WTP Improvements

Since 1965, the Flint WTP has remained a secondary or backup supply system to the DWSD primary supply. Typically the secondary supply for a public water system is expected to be needed only during emergency situations and normally is designed for short term operation such as providing the average daily demand for a few days. Conversely, Phase I improvements were designed with the intent to upgrade the Flint WTP in order to allow for an extended short term period (6 weeks) because of the perceived high risk that the DWSD supply would fail and remain out of service for an extended duration. Regardless, the Flint WTP was still intended to serve as a standby plant and as such the Phase I improvements lacked redundancies that would be required for a primary supply WTP.

2. Past Pilot Study & Testing

During design of the Phase I improvements a treatability study was completed by Alvord, Burdick & Howson, LLC (AB&H) in 2002. The Treatability Study evaluated the current treatment processes that are in place at the Flint WTP today with the Flint River as the source. The report recommended the following:

TABLE 2 – 2002 WTP TREATMENT RECOMMENDATIONS			
Treatment	Purpose	Point of Application	Dosage (mg/l)
Sodium permanganate	Zebra mussel control	Intake	0.3
Ozone	Taste & odor removal, disinfection	Diffusor basin	1.5
Ferric chloride	Coagulation	Rapid mix	40
Coag aid polymer	Turbidity & TOC removal	Rapid mix	2.0
Floc aid polymer	Turbidity & TOC removal	Floc basin	0.05
Lime	Softening	Softening basin	175
Soda ash	Softening	Softening basin	52
Carbon dioxide	pH adjustment	Recarb basin	37
Media filters	Filtration	Na	Na
Chlorine	Disinfection	Filter effluent	1.0

Of the recommended items, zebra mussel control, coagulant and flocculation polymer aids, and soda ash feed have not been incorporated into the treatment process.

3. Phase II WTP Improvements for Full Time Operation

Phase II WTP improvements are those needed to convert the Flint WTP from a back-up supply to a primary supply plant. A number of improvements have already been constructed as they were necessary to operate full time, treating water from the Flint River. The improvements under the title of Phase II that have been completed or are nearly complete include upgrades to the lime sludge lagoon, the lime sludge lagoon decant and disposal system, decant pump station and force main, installation of mid-point chlorination before filtration, and upgrade of the electric feed sub-station.

Additional improvements to the Flint WTP that are to be completed to become part of the normal treatment process using water supplied by the KWA are:

- New oxygen and nitrogen storage facilities for the ozone system
- New coagulant feed system
- Electrical
  - Pump Station #4 upgrades
  - Plant 2 improvements
  - Filter press building feeder
  - SCADA and controls upgrades
  - Filter transfer pump station feeders
- Installation of the future raw water feed connection point for the KWA
- Pump replacements and VFD installation in the low and high service pump station
- Filter transfer pump station to Dort Reservoir
- Facility security improvements

II. SOURCE WATER EVALUATION

A. DATA ANALYSIS

Based on past data collected and the 2002 Treatability Study by AB&H, the Flint River water quality varies seasonally with higher hardness and alkalinity experienced in the winter. Higher magnesium concentrations are also experienced in the winter, adding difficulty to the settling process due to neutrally buoyant floc. General water quality average characteristics recorded for the 2002 Treatability Study as compared with average characteristics recorded this year are shown in Table 3 below.

TABLE 3 – FLINT RIVER WATER QUALITY CHARACTERISTICS

Period	Turbidity NTU	TOC Mg/l	Alkalinity Mg/l	Hardness Mg/l as CaCO3	pH	Total Col. Count/day
2001 Apr–Oct	7.9	9.4	215	272	8.1	870-1230 (7300 max)
2014 May–Oct	8.3	10.3 5/22/14	207	252	8.2	1900-9000 (48,300 max)

Other than total Coliform, the Flint River characteristics do not appear to have changed significantly over the past 10+ years. Note that further investigation by City staff revealed a sewer leak upstream of the plant that likely was contributing to the total Coliform count.

B. CONCLUSIONS

Considering the minor changes in Flint River water quality, much of the information contained in the 2002 Treatability Study by AB&H remains relevant today. Data from that report assumed to be consistent today include the following:

- Flint River is influenced by groundwater from a dolomitic aquifer
- Hardness varies seasonally with higher hardness and alkalinity in the winter
- Hardness, alkalinity, magnesium concentrations tend to be reduced by run-off
- Total THMFP is likely 380-440 micrograms per liter as measured between April 2001 and January 2002. The City intends to re-test the raw water to confirm the THMFP has not changed. Results are pending.

In development of the 2002 Treatability Study, processes were simulated which resulted in low THMFP. Therefore, information contained in that report will be used to assist with establishing a baseline jar testing procedure discussed further in Section III.

III. TREATMENT PROCESS EVALUATION

A. EXISTING PROCESS DESCRIPTION

The existing WTP consists of an intake with screening from the Flint River, low lift pumping, ozonation, rapid mix, flocculation, settling, softening, recarbonation, filtration, storage and high service pumping. A process diagram is shown as Figure 1.

1. Intake

A 72" diameter pipe draws water from the Flint River through 2 traveling screens to the low lift pump structure. No chemicals are currently fed for Zebra mussel control or pre-oxidation as recommended by the 2002 Treatability Study. Manual removal of zebra mussels proved to be more economical than installation of chemical feed equipment considering the short term need.

2. Ozone

There are 2 ozone generators designed to provide adequate ozone for a WTP flow of up to 36 mgd. There are 3 ozone contact basins. The ozone generators were designed to produce 900 lbs/day at 10% concentration and up to 1300 lbs/day at 6% concentration each. Recent readings have indicated a production rate of approximately 700 lbs/day at 4% concentration. While serving the purposes of taste and odor control and disinfection, it is possible the current ozone feed might not be optimized to realize additional TOC removal benefits demonstrated by previous tests. Also, less than optimal ozonation has led to increased chlorine feed.

3. Rapid Mix

East and West rapid mix chambers allow chemical feed prior to the flocculation basins. Each rapid mix chamber is equipped with a 5 hp mixer.

4. Coagulation / Flocculation

The WTP contains two equally sized flocculation basins, east and west, and each basin provides tapered or gradually slowed mixing from inlet to outlet. There are fifteen 2 hp mixers for each basin with VFDs to control mixing speed. The 2002 Treatability Study recommended feeding both coagulation and flocculation polymer aids. Neither polymer aid is being used today because turbidity and TOC removals have been sufficient to meet regulatory requirements.

5. Settling

Primary clarification takes place within 3 basins containing plate settlers. The settlers are operating as designed.

6. Softening

Again, there are two basins for softening: east and west. Each basin is 120' in diameter and contains a solids contact softening unit. Each softening basin/unit has a design capacity of 18 mgd. Low lift pumping limitations, flow control to the basins, and fluctuating demands have made it difficult for WTP staff to stabilize the softening process. Softening is accomplished by feeding lime. The decision was made by the City not to feed soda ash in order to remove non-carbonate hardness because acceptable hardness levels could be achieved with lime feed only and softening is short term until Lake Huron water becomes available.

7. Recarbonation
Recarbonation for pH adjustment is accomplished in east and west recarbonation basins between and to the north of the softening basins. Carbon dioxide storage and feed equipment is located west of the recarbonation basins.

8. Filtration
Filtration is accomplished with 12 dual media filters, equally sized and designed to filter 3.0 mgd each. Media consists of 12″ of sand and 18″ of anthracite. The filters have been operated intermittently over the years due to the standby nature of the WTP and until recently, chlorine injection took place downstream of the filters. It is possible some microbial growth has developed in the filters.

9. Disinfection
Limited disinfection is provided by ozonation, but the primary form of disinfection is chlorine fed prior to filtration and prior to finish water storage / high service pumping. The intermediate chlorine injection location was recently constructed under the Phase II, Segment 1 contract.

10. Clear Well & Pumping
The pump building sits adjacent to a 3 MG clear well and contains both low and high service pumps.

B. JAR TESTS / EXPERIMENTS

1. Approach
There are several well practiced methods by which DBPs can be reduced. First, the disinfectant can be changed to an alternate that has a lower tendency to form DBPs. Second, additional treatment systems such as activated carbon or air stripping (depending on the nature of the precursors) can be added to remove DBP precursors. Lastly, the existing treatment processes can be optimized to remove as much DBP precursor as possible. Of these options, optimizing existing treatment processes is the only strategy that does not require the construction of new and expensive facilities. It is anticipated that Flint will be receiving Lake Huron water in approximately two years and this water will have a completely different chemistry from the Flint River. Major process changes instituted to address THM levels using Flint River water are likely to be unnecessary for Lake Huron water and may even be inappropriate. Therefore, those options which require addition of new treatment processes are undesirable at this time. In recognition of this upcoming change in water source, this study will concentrate on improving the existing processes, rather than adding new ones. New treatment processes will only be recommended if operational changes to the existing treatment train prove ineffective.

Recent sample test results suggest that most of the DBPs are formed in the distribution system rather than within the treatment plant. Therefore, the most logical approach is to reduce the DBP formation potential (DBPFP) rather than simply lowering the levels of DBPs leaving the plant. During bench scale testing, formation potential (FP) levels will be the primary indicator of success or failure of any proposed process modifications.

2. Protocol
Bench scale pilot testing is intended to reflect actual plant operating and hydraulic conditions so the bench scale treatment units will be sized based on various dimensionless factors to ensure the pilot treatment matches the actual system. Bench scale ozonation is not practical due to time and cost limitations. Therefore, water

samples will be withdrawn following the plant ozone basin. These samples will be transported to the laboratory where they will be dispensed into square testing jars. The jars will act as rapid mix, three-stage flocculation, and settling. Rapid mix and flocculation conditions will be matched to the plant based on "Gt" values. The "G" value is a measure of the mixing intensity and is a function of mix time, viscosity of the liquid, and mixing power applied to the water. "Gt" then, is a size scaling factor where time has been accounted for. Settling time will be scaled to match the shorter settling depth of the testing jars. After settling, samples will be decanted from the test jars. The decanted samples will then be lime softened; softening conditions will be similarly matched on the basis of "Gt". Fluoride will be added and carbon dioxide sparged into the samples to reduce the pH. The water will then be vacuum filtered through filter paper, sized to simulate the plant's dual media filters. The samples will be dosed with excess chlorine and allowed to react for seven days before testing for DBPs to determine the formation potential.

Although these conditions may be refined based on new information, we anticipate the following:

TABLE 4 – BENCH SCALE TEST MIXING INTENSITIES

Process	G	Duration
Ozonation	Plant	-
Rapid Mix	350	25 sec
Flocculation, Stage 1	50	9 min
Flocculation, Stage 1	25	9 min
Flocculation, Stage 1	12	9 min
Settling	na	10 min
Softening	TBD	10 min
Recarbonation	na	na

It is expected that the primary variables during the testing will be chemical additions and chemical dosages. Specific chemicals and dosages used for initial testing conditions will be selected to reflect current plant usage and the recommendations of the 2002 Treatability Study:

TABLE 5 – BENCH SCALE TEST CHEMICAL FEED RATES

Chemical	Current Usage	2002 Study
Ozonation	4.66 mg/l	1.5 mg/l
Ferric Chloride	7.7 mg/l	40 mg/l
Coagulant Aid Polymer	Not used	2.0 mg/l
Flocculation Aid Polymer	Not used	0.05 mg/l
Lime	120 mg/l	175 mg/l
Soda Ash	Not used	52 mg/l
Cationic Softening Polymer	3.13 mg/l	Not used
Anionic Softening Polymer	0.88 mg/l	Not used
Fluoride	0.45 mg/l	1 mg/l
Carbon Dioxide	32 mg/l	37 mg/l
Chlorine	6.3 mg/l	1 mg/l

3. Considerations

The 2002 Treatability Study did not note significant formation of DBPs. This may be a function of different Flint River water chemistry at that time. However, recognizing the considerable differences in chemical usage and dosages between that study and current operations, those differences in chemical use and dosage are an obvious starting point for optimizing treatment to prevent DBP limit exceedance.

Although it is believed that optimization of current treatment can correct the DBP issue, should optimization of present treatment prove insufficient, alternate residual disinfectants (chloramines and chlorine dioxide) will be investigated as additional treatment measures.

4. Results

To be completed following jar testing and experimentation.

5. Conclusions

To be completed following jar testing and experimentation.

IV. DISTRIBUTION SYSTEM EVALUATION

EPA guidance for the distribution evaluation portion of an OER is focused on identification and isolation of a specific portion of the distribution system that led to the exceedance. The circumstances of Flint's apparent pending TTHM exeedances are unusual in that a new supply has been implemented which clearly corresponds to the high TTHM sample results. Despite obvious implications to the primary cause of increased TTHM levels, value remains in evaluating the distribution system as there may still be distribution improvements that can be made to help alleviate the problem.

Evaluation of the distribution system, including modeling, was recently added to LAN's scope of services. When finished, information will be provided to complete the following topics in this section.

A. INFRASTRUCTURE

1. Piping

Main break history information available?
List pipe data for system… age, material, size

2. Storage

Considering drop off in demands in recent years, are storage tanks oversized?
Do they have mixing, baffling, other, to prevent stagnant water?
Are tanks in good condition?

3. Pump Stations

Condition of pump stations?
Pumps oversized?
Are valves working properly to maintain pressure zones?

B. OPERATIONS AND MAINTENANCE

1. Pump Station & Storage Operations

Are pressure districts set up properly?
Cedar Street Pump Station – no established pressure zone? Talk to Flint
West Side Pump Station – no established pressure zone? Talk to Flint
High and low levels in tanks optimally set? Should they be adjusted to use less storage volume?

2. Booster Disinfection Practices

They don't have any, do they?

3. Changes in System Demands

Long term decline in demands
Short term fluctuations – max day in winter due to large number of main breaks

C. WATER SYSTEM HYDRAULIC MODELING

1. Simulation of Existing System

Match existing conditions, particularly chlorine residual. We have chlorine feed data at plant and residuals at 10 locations in each MOR, May-October.

2. Identification of Deficiencies

Specific issues to look at:

Worst case at minimum daily demands
Water age in entire system
Recirculating water through pump stations
Use of storage tanks
Indications of broken valves

V. RECOMMENDATIONS TO MINIMIZE FUTURE OEL EXCEEDANCES

A. SOURCE

The City of Flint has already committed to the change from the Flint River as the water source to Lake Huron under the KWA system, planned for late 2016. The risk of future TTHM limit violations will decline substantially with the use of water from Lake Huron due to much lower DBP precursors. It is important to recognize that the Flint River will become strictly an emergency supply when the KWA supply becomes available and any investments toward the Flint River should be contemplated accordingly. Recommendations discussed below in this section apply to the Flint River as the source.

Reverting to supply from the DWSD until the KWA supply is available as an option. However, the DWSD has stipulated that a $4 million connection fee would apply and current water rates would include approximately $900,000 / month flat fee plus usage charges. Therefore, utilizing the DWSD for interim supply is cost prohibitive under the terms defined by the DWSD.

1. Watershed Management

A volunteer group entitled the Watershed Coalition performs various tasks related to managing the Flint River watershed such as spring cleanups and annual benthic studies to evaluate the river 'health'. No additional action is recommended at this time.

2. Monitoring

The City documents typical raw water characteristics as part of standard preparation of Monthly Operating Reports (MOR). No changes are recommended at this time.

3. Intake Operations

The 2002 Treatability Study recommended pre-oxidation in the form of sodium permanganate as a feed at the intake. However, pre-oxidation with sodium permanganate is unlikely to provide significant oxidizing of organics beyond that provided by ozonation. It is possible the addition of hydrogen peroxide would enhance the ozone process.

4. Seasonal Strategies

Past data indicates the Flint River is influenced by groundwater and in particular, dolomitic spring water. The result is hard water with high concentrations of magnesium and sulfate. Also, hardness and alkalinity are higher during the winter. Upon initiation of supply from the Flint River, the City made the decision to soften with lime only to focus on removal of carbonate hardness. One potential modification that could assist with TOC removal and thus decrease THMFP would be lime and soda ash softening. If implemented soon, the procedural change would be timely as it would also address increased hardness expected going into this winter.

5. Upstream Contamination Issues

Upstream contamination issues are extremely difficult to prevent and even if detected are difficult to locate. Evaluation of raw water data collected for MORs is the easiest manner in which to detect upstream contamination issues because the data is already collected for treatment purposes. In fact, high total Coliform readings signaled a potential issue recently that the City found to be a sewer leak, which was subsequently repaired.

An upstream monitoring and warning system could be established to attempt to detect spill event type contamination early enough to cease intake prior to the contamination reaching the WTP. However, given the imminent conversion to the KWA supply, the period of full time use would likely be far too short to achieve payback on the capital expenditures.

B. TREATMENT PROCESS

1. Operational Recommendations

- Coagulation and flocculation polymer aids: The 2002 Treatability Study suggested the use of coagulation and flocculation polymer aids. These polymer aids were shown in the 2002 Treatability Study to increase TOC removal and thereby reduce THMFP. Further evaluation will be completed during jar testing. [what would need to be done to the system to allow feed?? Could it be done easily??]
- Discontinue softening bypass: The City was previously bypassing a portion of flow around the softening basins because hardness levels did not warrant softening of the full stream. However, this practice was discontinued because it was believed the bypass stream was contributing to chlorine demand and preliminary data has supported that belief. Chlorine demand dropped 0.5 – 1.0 mg/l following elimination of the bypass stream in early November 2014.
- Soften with line and soda ash: Research has shown that enhanced softening with both lime and soda ash may provide additional TOC removal. The efficacy of this option will be evaluated during jar testing.
- Disinfection of filter beds: In case there has been microbial growth it is recommended the filters be ‘shock’ treated with chlorine and rinsed. A chlorine injection point was added upstream of the filters during the first segment of Phase II so future growth in the filters should not be an issue.
- Optimization of all existing treatment processes: Depending on bench scale testing conditions and results, slight modifications to all treatment processes might in order to replicate lower DPBFP.

2. Infrastructure Change Recommendations

- Fix and/or replace faulty ozone equipment: Since the ozone equipment was installed it has not been used extensively so the hope is that major components remain in good condition and the system can be easily modified to restore proper functionality. The City has scheduled the equipment manufacturer to field inspect the system on December 15, 2014.
- Change disinfectant to chloramine or chlorine dioxide: If other options prove to be ineffective, conversion to another disinfectant should be fully evaluated. Various characteristics of chloramination indicate an advantage over chlorine dioxide, but a full analysis would provide clarity as to which would be preferred.
- Install pre-oxidant chemical feed: Hydrogen peroxide as a pre-oxidant can enhance the activity of the ozone. This option is listed as a consideration only if problems continue with ozonation.
- Repair upstream sewer leak: a sewer leak upstream of the WTP intake was discovered and has already been repaired by the City.

C. DISTRIBUTION SYSTEM

Recommendations will be incorporated into this report when available. It is anticipated details will be provided for the following topics.

1. **Manage Water Age**
   a) **Storage Tanks**
   b) **Residence Time in Pipes**

2. **Reduce Disinfectant Demand**
   a) **Flushing**
   b) **Cast Iron Pipes**

3. **Water Modeling of Recommendations**
   Determine best flushing locations to reduce water age
   Changes to storage tank operating levels to reduce water age
   Valves to close/add to improve pressure zones, reduce recirculation
   Optimization of pump station use – smaller pumps? Shut down?

A number of actions have already been taken in terms of the distribution system. Water main flushing efforts were increased until late November when freezing weather became prevalent. Also, numerous valves that were broken in the closed position and believed to have been contributing to stagnant water were replaced.

D. BOOSTER DISINFECTION

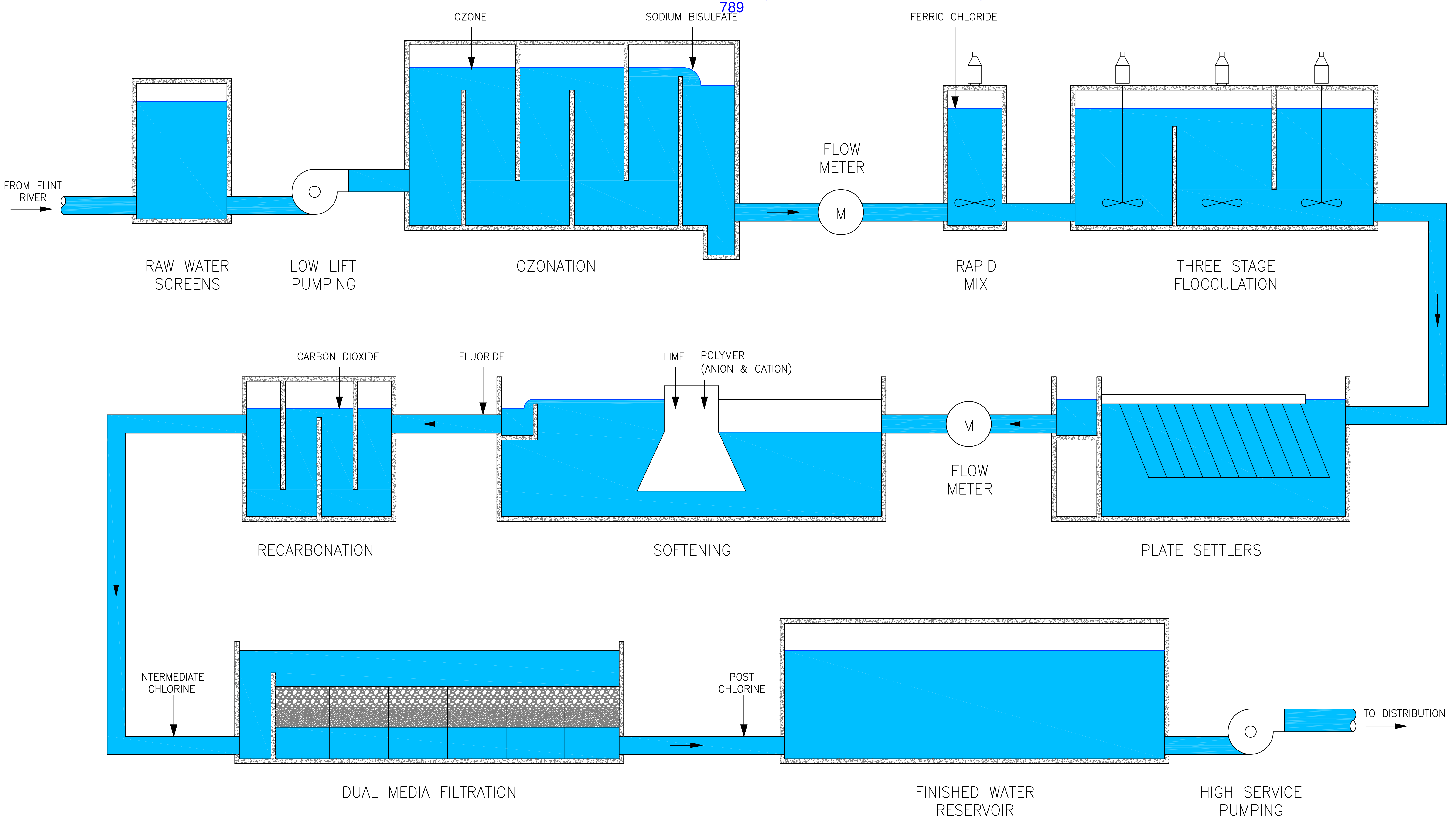
Decreasing chlorine feed at the WTP and adding booster disinfection in the distribution system is an alternative intended to reduce the reaction time at higher concentrations of chlorine to reduce DPB formation. Extensive looping and branching within the existing system would require numerous booster feed points and water system modeling to determine the most effective feed point locations. As a result, booster disinfection would likely not be cost effective. Further discussion and details will be provided when the distribution evaluation results are available.

E. CATEGORIZATION OF ACTIONS

Considering that the Flint River is being used as the water source only until the KWA supply is available (expected late 2016), options to address high THM formation that require new construction or extensive time to implement are not preferred. On the other hand, the City understands THM sample results to date dictate that some action is necessary. Two categories have been developed to assist the City in prioritizing actions to take. Stage 1 consists of actions that can be completed relatively quickly without major construction and Stage 2 actions are either long term actions or solutions requiring major construction. Stage 1 actions are to be completed first followed by evaluation of the results prior to consideration of Stage 2 actions. Grouping of actions are shown in the table below.

TABLE 6 – ACTION PLAN		
	Action	**Purpose**
Stage 1	Troubleshoot ozone feed system	Reduce chlorine feed and increase TOC removal
	Bench scale jar testing	Optimize treatment process and evaluate possible modifications
	Discontinue softening bypass	Reduce chlorine demand
	Disinfect filters	Reduce chlorine demand
	Increased water main flushing	Reduce water age / stagnant water
	Water system modeling evaluation	Determine areas with high water age and reasons
	Implement coag. & floc. polymer aids	Increase TOC removal
	Lower high water level in storage tanks	Decrease water age
Stage 2	Repair ozone system	Reduce chlorine feed and increase TOC removal
	Continue increased water main flushing	Reduce water age / stagnant water
	Convert to lime and soda ash softening	Increase TOC removal
	Continue valve replacements based on water model	Reduce water age / stagnant water
	Change disinfectant to chlorine dioxide	Reduce THMFP
	Install pre-oxidant feed at intake	Optimize ozone disinfection, reduce chlorine
	Place priority on replacing cast iron water mains	Reduce chlorine demand

Samples were taken the week of November 17th for the 3rd quarter of testing. Although the City has begun implementation of Stage 1 actions, THM results are not expected to be noticeably affected since there has not been enough time for a response. The next quarter of sampling is due to be completed the third week in February. It is the City's intent to implement Stage 1 actions prior to the 3rd quarter of THM sampling. [need to make sure Flint is good with this]



Genesee County

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
PLANNING ENGINEERING PROGRAM MANAGEMENT
1311 S. Linden Road, Suite B
Tel 810-820-2682 Fax 810-820-2703
www.lan-inc.com

CITY OF FLINT
WATER TREATMENT PLANT

REVISIONS			FILE LOG	
NO.	DESCRIPTION	DATE	ACTIVITY	BY
			Manager	JWG
			Design	
			Drawn	JRH
			Check	JRH

WATER TREATMENT PLANT
PROCESS DIAGRAM

Project No. 130-10701-001
Date Nov. 21, 2014

Sheet
FIG 1

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EXHIBIT M

Michigan

Officials say Flint water is getting better, but many residents unsatisfied

By **Ron Fonger | rfonger1@mlive.com**
on January 21, 2015 at 9:41 PM

FLINT, MI -- City and state officials said Wednesday, Jan. 21, that Flint is making strides in controlling total trihalomethanes in drinking water, but a skeptical crowd of residents at a town hall meeting seemed unconvinced.

Flint water customers, some carrying bottles of discolored water, packed the meeting, designed to spell out the city's efforts to improve water quality, but Department of Public Works Director Howard Croft ended the session before answering all the questions submitted in writing, and many residents walked out or tried to shout their questions and comments.

"People want solutions faster," said Brittany Reese, who said she came to the meeting to hear how she can protect her health -- even if it means adding extra filters to her home.

"We're not satisfied, but people are trying to nitpick the whole system," Reese said of the crowd. "There's obviously a serious problem with the (system)."

The quality and cost of Flint water has increasingly become a top priority for customers, the City Council and Mayor Dayne Walling, who this week **called on Gov. Rick Snyder for help** in addressing the problem, partly with millions in state or federal funds to fix the city's aging water transmission system.

FLINT WATER

'Beginning of the end' for Flint water crisis health disaster, Edwards says

Watch live as new Flint water test results are announced by Virginia Tech

Water resources sites up and running in all nine Flint wards

W.K. Kellogg Foundation awards $7.1 million to help Flint families

No 'smoking gun' against ex-state water chief in Flint crisis, lawyer says

All Stories

Water customers were told earlier this month that the city is in violation of the federal Safe Drinking Water Act because of the high level of trihalomethane (TTHM) in drinking water samples last year.

TTHM is a byproduct of chlorinating river water. The notices sent to water customers say Flint water is safe to drink but warns those with "a severely compromised immune system, (who) have an infant or are elderly" that they "may be at increased risk and should seek advice about drinking water from your health care provider."

TTHM became a problem for the city after it ended a 50-year relationship with the city of Detroit for purchasing treated Lake Huron water and began treating Flint River water instead.

The city and county are partners in the Karegnondi Water Authority, which is building a pipeline to Lake Huron to bring lake water here for use by the end of 2016.

That's not soon enough for for many, including Claire McClinton, a member of the Flint Democracy Defense League and one of about 150 people at the meeting.

"This was, as far as coming to a solution, a total waste of time," McClinton said. "To me, (the water is) like somebody dropped a bomb on this city. We don't need to test. We know (it's a problem)."

Officials from the state Department of Environmental Quality reviewed issues, including bacteria and TTHM, that Flint water officials have dealt with since switching to river water. They continued to advise those with concerns to consult their doctors about whether to drink it.

"Is there a risk in the short-term? That depends on you ... it's an individual thing," said Steve Busch, Lansing and Jackson district supervisor in the DEQ's office of drinking water and municipal assistance. "You can make a judgment (after talking to your doctor)."

State and city officials have said exposure to TTHM is a long-term concern for some if they drink water with elevated TTHM for several decades.

City Councilman Scott Kincaid said after Wednesday's meeting that there will continue to be problems with Flint water until the city again uses lake water.

"The only solution I see in the short-term is getting Lake Huron water back in our system so people feel the water is clear and safe," Kincaid said.

Emergency manager Jerry Ambrose told members of the council before the water meeting that officials plan to continue efforts aimed at fixing the entire city water distribution and treatment systems.

"There's nobody in this administration that's happy with the quality of the water," Ambrose said. "We're not satisfied having had to have put (a notice of violation) out."

Although the Detroit Water and Sewerage Department has said it is "ready, willing and able" to start selling Lake Huron water to Flint again, city officials here have said Detroit's offer is too costly and would increase the cost of water by by more than $12 million annually.

EXHIBIT N

VEOLIA

City of Flint, MI – Go / No Go Memo
January 22, 2015

FROM
Jonathan Carpenter

TO
Harald Jensen, Mike Byrnes, Bill Fahey, David Gadis & Rob Nicholas

Deal Highlights

This project is an emergency review of the water plant and distribution system for ways to improve water system compliance on chlorine, bacteriological tests and reduce THM formation. It is a required study by the State of Michigan in response to violations. It is an emergency procurement with only 11 days' notice because of a public crisis in confidence of the water.

Overview

On May 1, 2014 the City of Flint discontinued buying water from Detroit Water and Sewer Department and began treating water from the Flint River. In the subsequent months, the distribution testing resulted in low chlorine residual levels and positive tests for total coliform resulting in the issuance of boil water notices for precautionary measures. Numerous valve replacements and additional chlorination resulted in more consistent chlorine residuals throughout the system.

Quarterly reporting to the Michigan Department of Environmental Quality (MDEQ) of Disinfectant Byproduct Levels resulted in trihalomethane (THM) levels above the maximum contaminant level (MCL triggering a violation notice from the MDEQ dated December16, 2014. The City has worked with an engineering firm to develop an Operational Evaluation Report as required by the violation and has submitted that report to the MDEQ. Initial implementation of the suggestions has resulted in lowering of contaminate levels but not to a point of compliance. The next testing period is scheduled for the middle of February 2015 and an updated Operational Evaluation report which incorporates the results of that test is due to the MDEQ no later than March 1, 2015.

A long term solution will occur in 2016 when the City will access a new water supply from Lake Huron via the Karegnondi Water Authority. Between now and then the City needs to find a solution. DWSD has offered to provide water to Flint but the City abandoned that source of water already due to high costs. Flint like Detroit is under an Emergency Manager because of dire financial problems. Reconnecting with DWSD would immediately resolve the water quality problems but cost $12M a year.

Requested Scope of Service

The City is seeking a consultant to immediately review and evaluate the water treatment process and distribution system, provide recommendations to maintain compliance with both state and federal agencies, and assist in implementing accepted recommendations. The City will have the selected vendor provide reports to reflect their findings and provide continual oversight in implementing any approved recommended practices to improve the quality of water until implementation of the KWA project. These reports will be made public in an effort by the City for full transparency in this crisis.

The City is requesting that the selected vendor provide coordination in implementing any selected recommendations that will result in improving the overall process of treating and distributing water until such time that the City is receiving and successfully treating Lake Huron water. It needs to be pointed out the City pro-actively hired Lockwood, Andrews and Newman to do a study when they knew problems in the system were occurring last year. The actions suggested in that report are working in reducing the problem. The report requested in this RFP is simply an extension of that report per State and EPA regulations. The City is under great stress. Recent newspaper article discusses an unruly crowd at a public hearing. The City web page is full of the detailed actions being taken by the City.

Procurement Process

Proposals are due next Monday January 26, 2015. This emergency time frame provided only 11 days' notice for vendors. Without an extension it would be difficult to prepare and submit a legitimate proposal. An extension however is unlikely due to the crisis being faced by the Administration. No time for questions and tours was provided. A discussion with the Mayor of Flint has prompted our considering the project based on his concerns and need to solve the problem.

The RFP requests a lump sum fixed price for the submittal of the reports and then an hourly fee thereafter for implementation assistance. A lump sum price for us now is a guess without any on site visit and evaluation of data. Of course we do not like the hourly fee. One way to respond is to provide an hourly fee ($225 an hr.) and agree to negotiate a lump sum fee based on a site visit and meeting to discuss the problem. A $50k fee for the study is likely but implementation costs are unknown.

Procurement Process

The project would require primarily a water expert like Marvin Gnagy. There is great demand for this expertise in the company. The Camden RFP would need help also. Whoever named in the letter would need to be ready to go almost immediately to work on the project. The report is due by March 1 but the City needs to mollify the public that action is being taken. Some communication or graphic help may also be needed. The report is sure to be published on the city web page (like all other material related to the crisis).

Competition

Lockwood, Andrews and Newnam are an engineering firm with offices across the country (TX, LA, FL, AZ, CA & MI). They have an office in Flint as well as Lansing. Price is noted in the RFP as a key factor and a 7% advantage is given to a firm with an office in Flint. Likewise the firm already provided the first study which was accepted by the state and whose implementation is working. Other local engineering firms will be bidding on this opportunity and we may see United but there has been no intel back that they have picked up the RFP. Our operations background may prove intriguing however to the City as better help.

Win Strategy

Any pursuit at this point would be limited to a letter proposal with an hourly fee and commitment to provide a fixed fee upon more review. The short time frame of the procurement would make that a reasonable response.

The letter may be more important to simply position us and make Flint aware of our capabilities for longer term assistance. The City is in financial trouble and needs help. The utility has a $50M+ OpEx budget using 117 employees to run the WTP, 600 miles of water line, 1500 miles of sewer and a 50 MGD WWTP.

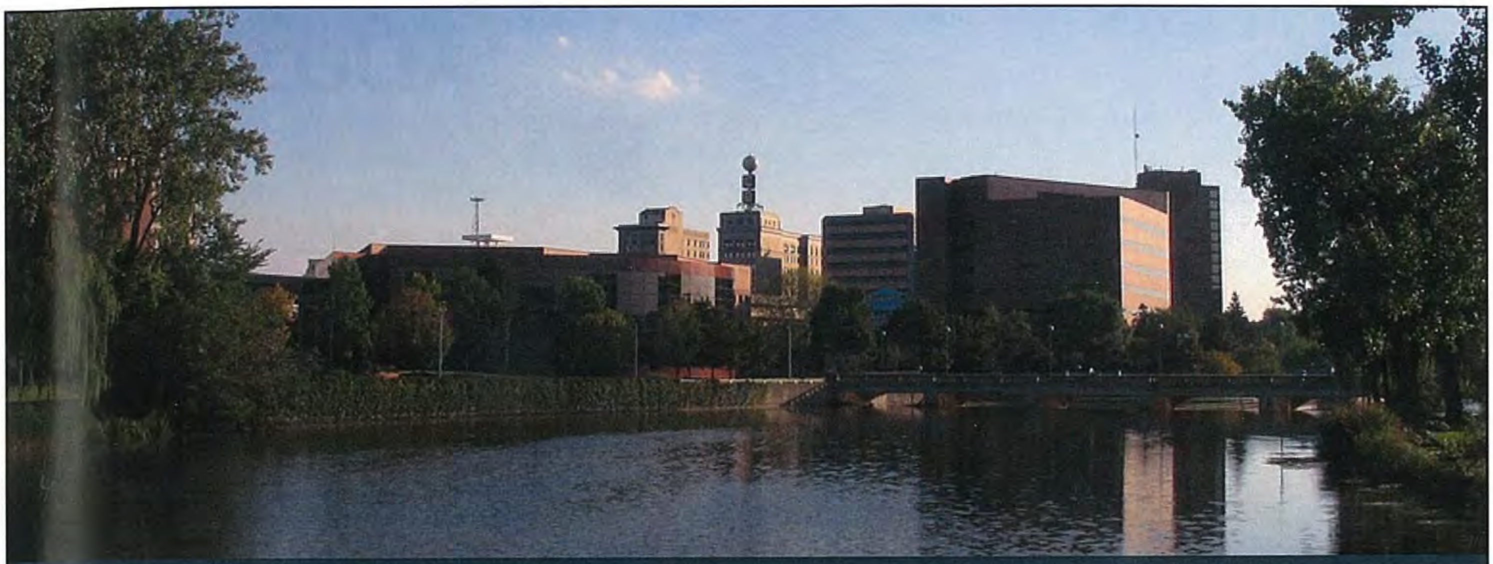
The current engineer seems well positioned to move quickly based on documents available. That however is not solving the public confidence problem. The City has an aggressive public campaign in place with public hearings and full transparency of actions. The public has a confidence problem in the water system now and there has been so much public outrage a public hearing was closed due to disruptions.

We have been working with a local communications firm that has great relationships with the City and newly appointed emergency manager. There have also been conversations with the Mayor and the Emergency Manager concerning Veolia and our offerings. The Mayor requested we respond to the RFP. He however may not have known the restrictions on time. If an extension can be granted allowing time to visit the plant, review records and submit a response then this could be a paid sales opportunity to expanding the project.

Decision

The purpose of this document is to develop a consensus on how to proceed. If a "Go" then a letter proposal would be submitted. If a "No" then a letter would be sent explaining the time restraint on responding but providing background on our ability to provide long term services as a follow up.

EXHIBIT O



Submitted to:

City of Flint, Michigan
Department of Purchases & Supplies

Response to Invitation to Bid

Water Quality Consultant

Proposal No.: 15-573

January 29, 2015

VEOLIA

VEOLIA

January 29, 2015

Mr. Derrick F. Jones
Purchasing Manager
City of Flint
Department of Purchases and Supplies
1101 S. Saginaw Street, Room 304, Third Floor
Flint, Michigan 48502

Subject: Response to Invitation to Bid – Proposal No.: 15-573
Water Quality Consultant

Dear Mr. Jones:

In response to your Request for Bid/Proposal (RFP), **Veolia Water North America Operating Services, LLC** (Veolia) is pleased to have the opportunity to provide this letter submittal. We have prepared a response that is focused on providing the **City of Flint** with a complete solution to address the immediate reliability and operational needs of your water system throughout your continuous operations – whether under the current draw from Flint River or future draw from Lake Huron.

In reviewing the challenges that the City of Flint is facing, we present a longer-term approach for the Operational Evaluation Report, which involves implementation and monitoring through 2016 and the transition to Lake Huron supply. Our commitment to the City of Flint is to make sure the utility can identify the immediate issues through the proposed report, and also secure its future by addressing and fixing these issues identified in the report, build capacity for the future, and better manage the change in water sources in 2016.

Depending on the City's preference, Veolia's expertise to reinforce operations is available to Flint through performance advisory services using our innovative Peer Performance Solutions (PPS), or through longer-term contract operation and maintenance (O&M) type services. Both approaches are designed to help the City of Flint benefit from operational reliability and utility-wide efficiencies.

With the PPS approach, Veolia addresses fundamental issues from the ground-up to deliver improved reliability, compliance and efficiencies for major water and wastewater agencies. Under this model, our Subject Matter Experts (SMEs) would work in collaboration with the City's management team, your line managers and your operators to develop the path forward that suits your needs – both now and into the future. Over the course of this process the City remains in control of all levels of management at all times and benefits from Veolia's expertise through the support of a small team of on-site experts, who in turn can access the rest of our company's worldwide resources.

Veolia's PPS approach is highly data-driven to identify and implement cost savings and deliver utility optimization and organizational best practices. One key example of this model at work is in our ongoing contract with the Pittsburgh Water & Sewer Authority (PWSA). That partnership began in 2012 and was just (this past month) extended for a new term. Working with PWSA, Veolia is implementing a long-term strategy to improve water quality and customer service, increase efficiency, and overcome financial challenges.

PWSA serves the needs of more than 310,000 people in the greater Pittsburgh area, and Veolia assisted them in realizing more than $5.5 million annually in recurring revenue and efficiencies. This involved working with PWSA to establish a Distribution System Optimization Plan with the State of Pennsylvania, to implement a Process Control Management Plan at their water treatment plant, to identify early warnings for non-compliance trends, to update their laboratory Quality Control/Quality Assurance (QA/QC) program, to initiate performance monitoring methods, and to initiate the use of compliance metrics in order to improve relationships with regulatory agencies. We also implemented a Community Outreach Program to improve the public's perception of PWSA and create positive media attention for the agency.

Veolia is also applying the PPS model for New York City's water and wastewater operations. Under a contract that began in 2011, Veolia has reviewed all aspects of that utility's practices to assess potential improvements. Working collaboratively with the City's water and wastewater operators and managers, Veolia focused on areas including: chemical use and pricing; labor productivity; inventory management; sludge process optimization; and overall O&M activities. Under this approach, our firm identified opportunities that are expected to yield annual recurring financial benefits of more than $100 million by 2016 -- to date, more than $90 million in savings and revenue enhancements have been reported by New York City.

The highly collaborative PPS partnership model evolved as an alternative to Veolia's traditional O&M services delivery approach, an approach that our firm first applied over 42 years ago under the first municipal contract operations partnership in the U.S. – an ongoing partnership with the City of Burlingame, California. Today, our firm continues to use this model to provide water and wastewater services to over 160 municipal clients. To demonstrate the depth of our firm's award-winning experience in the operation of surface water plants we have included a list of Veolia-operated plants as an attachment to this letter. Veolia's contract operations services are also available to Flint, as an alternative to PPS.

In the remainder of this letter, we outline our approach to: providing immediate assistance related to the review and evaluation of the water treatment process and distribution system; development of recommendations and a report for maintaining compliance with both State of Michigan and federal agencies; and assistance in implementing accepted recommendations from the report. The report that Veolia would develop for the City would outline findings and provide recommendations for continual oversight of the approved recommended practices to improve the quality of water until the implementation of the Karegnondi Water Authority (KWA) project.

Veolia's Understanding and Proposed Approach to Providing the Water Quality Consultant Scope

Our longer-term approach would begin by addressing the immediate assistance outlined in your RFP, and then service beyond that scope. Under this expanded scope, Veolia would help with the transition from the Flint River source to Lake Huron water to avoid a repeat of this scenario. That transition is expected to be in place in 2016 and will complete the City's transition from using water provided by the Detroit Water and Sewerage Department (DWSD) to drawing water from the Flint River, using the City-owned water plant.

With a Notice of Proceed issued, Veolia would mobilize a team of experts, including our two prominent water SMEs, from our corporate Technical Services Group (an in-house team of technical and management experts that support the company's projects and operations throughout North America). These experts would include:

- **Marvin Gnagy, P.E. - Water Process and Quality Manager** – He has more than 37 years of water quality management experience, and is a certified Water Operator in Ohio and a registered Professional Engineer. Mr. Gnagy has completed projects that have involved the set of tasks that the City as defined under this contract, and was most recently engaged as a part of a Veolia team of experts that worked with DWSD and the City of Detroit on a program to evaluate their water and wastewater operations and proposed solutions. This included conducting an intensive due diligence examination of Detroit's water and wastewater facilities and operations, and the development of two reports, a Peer Review Report, which looked at the current operations with a focus on identifying immediate and long term needs, and a Transition Plan: Retail Services for the City of Detroit, which outlined the issues facing the DWSD and the City as the water and wastewater operations changed under a new regionalization approach. Through that work, Mr. Gnagy understands the City of Flint's drivers for this new project, and will be able to use the work that Veolia has done to date for the DWSD to aid in identifying the optimal solution for your water system and the transition from DWSD to your own operations.

  Mr. Gnagy's background and key experience that relates directly to the work scope outlined for Water Quality Consultant tasks includes:

  - River Water & Groundwater Treatment and Disinfection Byproducts (DBP) Reduction – Mr. Gnagy has very broad experience with both river water and groundwater treatment on project work involving unit process design and operations to meet drinking water standards and water quality goals. Indeed, he has

conducted numerous studies involving DBP (particularly THM) reduction to meet drinking water standards, establishing treatment alternatives and process targets for THM compliance solutions.

- Master Plan Development and Unit Process Improvements – Mr. Gnagy prepared the master plan and performed plant evaluations for unit process improvements to meet future drinking water standards for the City of Adrian, Michigan's10-MGD water treatment plant. That plan discussed multiple options for process improvements and chemical feed adjustments, specifically targeted for THM control treatment. Jar testing was used to define the chemical dosing and treatment scheme that resulted in the most effective THM reduction solution for the city. He also served as Project Manager for a DBP Reduction Study for the City of Akron, Ohio's 67-MGD water supply plant. That study reviewed jar testing evaluations and historical monitoring records to develop the necessary treatment process adjustments to effectively reduce THMs in the drinking water. Computer models were developed using the data obtained to predict the chemical treatment needs based on source water quality, and to predict THM concentrations following treatment adjustments using the chemical treatments selected. Recommendations included chemical feed adjustments and further study related to advanced treatment technologies.

  Other work in this area included serving as the Project Manager for an optimization study for the Village of Blissfield, Michigan's 2.2-MGD water treatment plant to determine needs for improved turbidity and THM concentrations. All major unit processes and chemical feed systems were evaluated for optimal treatment needs. Jar testing and plant operating adjustments were made weekly to improve water quality and process control. Implementation of organics control treatment was accomplished that successfully achieved compliance with both the turbidity and THM compliance requirements.

  Mr. Gnagy also conducted plant reviews, performed process design changes, designed new flocculation equipment replacements, and designed and started-up new washwater handling operations for several of DWSD's water treatment plants. That worked involved three plants, the Southwest, Lake Huron and Springwells water plants, and focused on improving operations and to meet drinking water compliance.

A full resume for Mr. Gnagy is provided as an attachment at the end of this letter.

- **Theping Chen, P.E. - Process and Operations Optimization Manager** - He has close to 30 years of water engineering, operations and research experience, and he spent 15 years as a water consulting engineer in Michigan and is a registered Professional Engineer in the State of Michigan. Mr. Chen's experience includes working with DWSD on various projects related to master plan, source water protection, water quality management, treatment process optimizations including PAC and ozone design criteria development, taste and odor control, residual management and capital improvement program development. He has also worked extensively with the Michigan Department of Environmental Quality (MDEQ) on compliance issues with focus on water quality compliance, and is a well-published author at the national and state level conferences.

  With Veolia, Mr. Chen has been engaged in supporting the ongoing operations and management contract for the City of Buffalo, New York's water operations, and in providing technical support for Veolia's water plant operations at the cities of Gloucester and Brockton, Massachusetts; with that work including jar testing evaluation and compliance strategies development for DBPs.

  Mr. Chen's background and key experience that relates directly to the work scope outlined for Water Quality Consultant tasks includes:

  - River Water and Groundwater Treatment – Mr. Chen has broad experience with both river water and groundwater softening treatment on projects including: on-call engineering, comprehensive needs assessment, filter and chemical system rehabilitation projects for the City of Marion, Ohio's 9.1-MGD water treatment plant (treating combined groundwater and river source water), under a scope of work that involved investigating DBP control strategies and conceptual design of a UV treatment system; a comprehensive regulatory review and capacity evaluation for the City of Dayton, Ohio's two groundwater water treatment plants (96-MGD each); and a comprehensive disinfection and DBPs compliance strategy review for the City of Ann Arbor, Michigan's water treatment plant (a combined surface and groundwater softening plant with at rated capacity of 27-MGD) as part of an overall Water Master Plan project.

- Ozone and Disinfection Technologies - His experience in this area included completing ozone system study, design, construction management and optimization projects for more than 10 municipal water treatment plants.
- DBP Compliance – Mr. Chen's experience in this area includes: optimizing and upgrading ozone systems, and proposing the use of biological filtration to enhance the TOC removal to control DBPs for the City of Shreveport, Louisiana's water treatment plant; optimizing chlorination application, conducting a review of contact time calculation to minimize DBP formation, and proposing UV system upgrades for the City of Marion, Ohio's water treatment plant; evaluating a commercial (self-fabricated) aeration system for installation in elevated and ground-level water storage tanks to reduce the hot spots in Northern Kentucky water treatment plant's water distribution system; and development of tracer test program to calibrate the water quality model for the City of Akron, Ohio.

A full resume for Mr. Chen is provided as an attachment to this letter.

These staff will be responsible for delivering on the immediate tasks that the City has defined:

- Reviewing and evaluating the City's water treatment process and distribution system. This will include evaluating the City's processes and procedures to maintain and improve water quality.
- Developing a report on the finding of the evaluation, with specific recommendations to maintain compliance with both State of Michigan and federal agencies. This will include outlining recommendations that will improve the water treatment and distribution system.
- Assisting the City in implementing accepted recommendations. This will include providing continual oversight and support for the implementation of any approved recommended practices. Recommendations will focus on those areas that will improve the overall process of treating and distributing water, including improvements to water quality until the implementation of the KWA project (anticipated to be by mid-2016) under which the City will be receiving and treating Lake Huron water.

In addition to Mr. Gnagy and Mr. Chen, our core staff group, would be assisted by other technical, operations, management and communications experts from Veolia to proceed promptly into implementation simultaneously.

We believe that addressing the fundamental issues concerning water quality compliance and operational reliability is much more complex than the recommendations study and advisory services approach outlined in your RFP.

We want to ensure that the utility can fix these immediate issues effectively and without delays, while at the same helping the City to begin to build capacity for the future and better manage the 2016 water source change in a systematic way – with all the relevant stakeholders engaged along the way.

In undertaking these tasks, Veolia understands that in 2014 the City completed the transition from using water provided by DWSD to drawing water from the Flint River – utilizing your own water plant to treat and distribute water to those served by your system. Since that transition process was completed, it was found that many of the City's eight water quality testing sites exhibited low chlorine residual levels, and several of those sites developed had positive tests for total coliform, which resulted in issuance of boil water notices for precautionary measures. To address this, the City implemented valve replacements and additional chlorination that yielded consistent chlorine residuals throughout the system. However, quarterly reporting to the MDEQ of Disinfectant Byproduct Levels resulted in trihalomethane levels above the maximum contaminant level (MCL), with an annual average level that triggered a violation notice from the MDEQ.

To date the City, working with an outside engineering team, developed and submitted to the MDEQ an Operational Evaluation Report. The next testing period is scheduled for the middle of February and an update to this report will be required by March 1, 2015. That update will incorporate the results of the tests required by the MDEQ.

The City is expecting to work with the selected Water Quality Consultant to complete the required testing and prepare the updated Operational Evaluation Report. As a secondary element of this task, the City is seeking to retain the selected Consultant to aid in the implementation of these suggestions.

Veolia excels at the day-to-day operation issues and understands how to fix them using diverse and subject matter expertise in a structured, bottom-up type, staff engagement process. That is why we designed the PPS approach to help convert the report findings into actionable items for the City of Flint's staff and then help them implement those changes. This would involves making sure that your staff understand why changes are being made, ensuring that they have the training necessary to make the changes, and then following up to be certain what is planned works or if not then provide help making adjustments. This will involve also a monitoring process to make certain the changes are on track for management and the public.

All of this can then be used to help the City to be prepared to begin receiving and treating raw water from Lake Huron through the KWA. The end goal of this process will be to develop within the City's staff a better understanding and capability to handle the changes in water, whether drawing water from the City of Flint's or the new KWA supply sources.

Veolia's Anticipated Level of Effort

In order to respond to the immediate needs of your defined scope of work, we anticipate mobilizing a team of technical, operations, maintenance and communications SMEs to: calibrate daily water quality samples with the City's hydraulic model; refine the operational strategies for the plant and distribution system; coordinate daily efforts across plant, operations and maintenance staff; and to alleviate continued concerns from the public through a public communications process. The elements of this approach would be delivered under a management and staffing approach which allows for collaboration between the City and Veolia's technical and management team.

For purposes of the scope of services outlined in the City's RFP, Veolia's core staff would be charged at a common rate of $225/hour, plus expenses.

For the longer-term type of approach, Veolia would set a single lump sum price for the study, implementation and long term services after review and discussion with the City on selecting your preferred approach – the PPS approach or the contract O&M approach. At that time, we can also explore an incentive-based (risk/reward) type of approach, one which is common under PPS contracts, where Veolia's fee is based on achieving performance targets that we would mutually agree upon. As demonstrated in our work with water and wastewater clients, Veolia's PPS model has provided great insight into working with large utility staffs to change the culture and ensure implementation of ideas that improve the utility's performance.

The methodology for implementing a PPS approach, as outlined on Figure 1 (below), includes each of the following steps:

- Preparation – This stage involves the mobilization of resources (Veolia and the City), a joint project kickoff meeting (Veolia and the City), development and implementation of a communications plan (Veolia and the

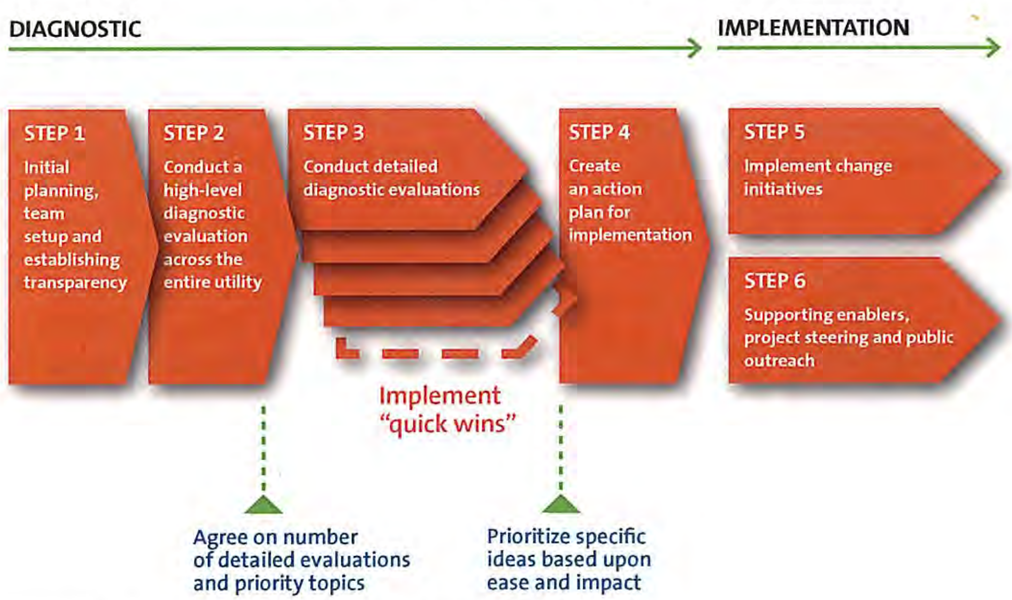


Figure 1. Veolia Peer Performance Solutions (PPS) – Service Delivery Model

City), and data collection (Veolia). The City and its consultants have already done a lot of work on the problem and are achieving some success.

- Top-down Analysis – This stage involves data analysis, benchmarking, field observations, interviews and idea generation workshops. This would be done to assure how effective current changes have been and if there are any additional actions to be taken.
- Bottom-up Analysis – This stage involves detailed analysis and modeling of the available options, working in collaboration with the City's management team and staff.
- Action Plan – This stage involves defining specific steps for a recommendation based on the actual, current state and desired state performance of an asset.
- Plan and Report – This stage involves the final development and delivery of a written report summarizing findings and presenting analyses and recommendations

These actions are what we would provide during the study phase of the project, and the following actions are what we would do to implement study recommendations

- Implementation – Putting plans into action. This involves working with O&M and management staff to carry out the proposed plan. This effort I focused on building capacity and confidence within the staff to solve the problem.
- Monitoring and Repeat – Monitoring the process and then repeating it, digging even deeper into the organization for additional savings and improvements.

Using this type of plan and approach, Veolia can address the immediate scope/needs defined for the Water Quality Consultant task, and work with the City of Flint to provide a long-term and sustainable approach for the needs of your water treatment and supply system.

Addressing the Requirements of the Invitation for Bid

Veolia recognizes that we are submitting this Proposal as an alternative approach for the City of Flint to consider within the procurement process that you have defined, and in that regard we are providing the other specific information that your have requested as part of the formal RFP response, including:

- Company's Information – Veolia Water North America Operating Services, LLC is the respondent, and the contact information for our firm is as follows: Veolia - 101 West Washington Street, Suite 1400 East, Indianapolis, IN 46204 - Telephone: 317/917-3700
- Firm Background and History – Veolia is a company that traces our history in providing operations and related services to municipal clients back more than 42 years. Today our firm ranks as the leader in the delivery of O&M and related services, including those under the PPS model. This include serving as the operator and manager of over 180 municipal wastewater systems (processing over 1.66 billion gallons a day of flow) and some 90 municipal water systems (providing over 715 million gallons a day of water).

  Today, Veolia ranks grown as the leading water services provider in North American market, with more projects, operations, resources, expertise and demonstrated success than any other services provider. This record of performance and market leadership is affirmed in the most recent survey from the publication Public Works Financing (opposite), which shows Veolia's better than 40% market share, with revenues and a renewal rate that lead the industry. What these market leading indicators serve to show is that we can meet the standards of experience and capabilities that the City of Flint is requiring under this new contract.

Water operators ranked by 2013 revenues

O&M and DBO market share reported by Public Works Financing (PWF) | March 2014

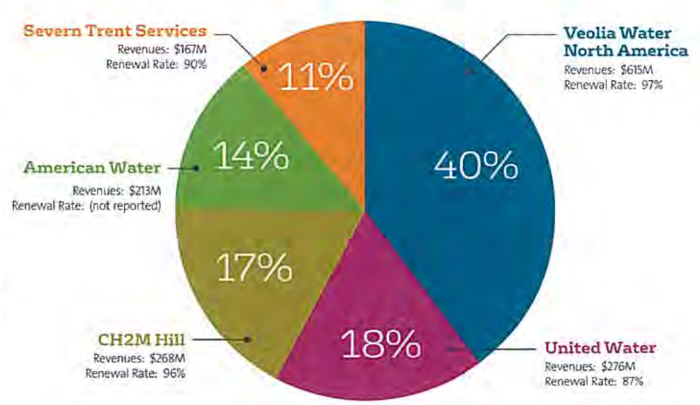


Figure 2. Veolia Service Delivery Models and Experience

Veolia Example →	NYC	Buffalo	Milwaukee	Indian-apolis	Baltimore Compost	Rialto California	Franklin Ohio
Options → Criteria ↓	PPS	Delegated Manage-ment	Single Activity O&M	Full O&M	DBO or T	Concession	Privatiza-tion
Ease of Procurement	🟢	🟢	🟢	🟠	🔴	🔴	🔴
Agreeable to Employees	🟢	🟢	🔴	🔴	🔴	🔴	🔴
Ease of Cancellation	🟢	🟢	🟠	🟠	🟠	🔴	🔴
Public Rate Control	🟢	🟢	🟠	🟠	🟠	🔴	🔴
Speed of Implementation	🟢	🟠	🟠	🟠	🔴	🔴	🔴
Ease of Permitting	🟢	🟠	🟠	🟠	🔴	🔴	🔴
Ease of Continued Use of Alternative Project Delivery	🟢	🟠	🟠	🟠	🔴	🔴	🔴
Ease of Acceptance by Other Stakeholders	🟢	🟠	🟠	🟠	🔴	🔴	🔴

- Firm Qualifications, Experiences and References - Like the City of Flint, we are at our core utility managers and service providers, and Veolia understands the need for high quality, efficient service and dependable reliability. We also work with communities like yours to deliver services under a variety of contract models, each focused on providing our municipal partners with the best value under a long-term and sustainable approach and customized to their objectives. Figure 2, above, outlines our experience with various service delivery models, each of which involves working with clients to develop a customized approach to meet their particular needs and objectives. This table also shows the key advantages of each type of service delivery approach, with **green** being optimal in terms of ease of execution and delivery and **red** being the most challenging and complicated in terms of delivery. This table also highlights example projects where our firm has successfully delivered each of these approaches (and many of those are highlighted under the reference projects section of this letter). What this table also shows is that Veolia can offer alternative transaction structures, including long-term lease, concession arrangement or sale/purchase.

  As we discussed above, Veolia currently operates and manages 90 municipal water systems (providing over 715 million gallons a day of water); at the end of this letter we have provided a summary table of this experience.

  Following here we provide some of the specific clients/projects as the core references that we are submitting for the City of Flint's consideration:

  - **Pittsburgh Water and Sewer Authority (PWSA), Pittsburgh, Pennsylvania** - The PWSA's Board of Directors unanimously selected Veolia in 2011 to deliver an innovative approach to managing the system, provide measurable results to customers and demonstrate an ability to quickly and easily collaborate with employees. In 2014, this management assistance/PPS contract was extended for a new term, recognizing the success of the effort to date.

    Since the beginning of this partnership, Veolia has assisted the PWSA in realizing more than $5.5 million in annually recurring revenue and efficiencies.

    PWSA provides water and sewer services to 310,000 people in the City of Pittsburgh and surrounding areas. The agency hired Veolia to: 1) provide interim executive management services, leading 270 public employees in the delivery of water and wastewater services in the greater Pittsburgh area; and, 2) conduct a study to identify ways to cut costs and improve service. Under a management assistance scope, Veolia has worked with the PWSA to establish financial controls that limit spending and increase accountability, foster competition among companies seeking to do business with and on behalf of the PWSA, and identify opportunities for operational efficiencies having a direct impact on the utility's bottom line.

Veolia in North America – Experience Profile

- 188 Municipal and Commercial Clients
  - 90 Municipal Water Treatment Facilities
    - 2,952 Miles of Distribution System Lines
    - 87 Water Pump Stations
    - 171 Water Wells
  - 183 Municipal Wastewater Treatment Facilities
    - 5,286 Miles of Collection System Lines
    - 1,158 Wastewater Pump Stations
    - 31 Industrial Pretreatment Programs
  - 13 Billing/Collection Operations
  - 23 Meter Reading Operations - 147,399 Meters Read
  - 4 Public Works Operations (other than Water/Wastewater)
  - 6 Operations Assistance/Peer Performance Solutions Projects
  - 53 Energy Installations (owned/operated/managed)
    - 631.6 MW of Energy Generation/Supply Capacity
    - 290,394 tons per day of Chilled Water Capacity
    - 443 MMBTU/hour Total Hot Water Capacity
    - 13.2 million pounds/hour of Total Steam Capacity
- 95 Industrial Clients
  - 60 Industrial Wastewater Treatment Facilities
  - 23 Industrial Water Treatment Facilities
- 913.3 Million Gallons Water Treated Daily
- 1.7 Billion Gallons Wastewater Treated Daily
- 293,089 Dry Tons of Biosolids Processed/Year
- 19.2 Million+ Population Served Daily

Under this contract, Veolia's management team is integrated into PWSA's organization to manage the agency's staff at their offices and operations sites, while another team of experts jointly identifies and evaluates improvement opportunities. This joint effort aims to help the PWSA improve the utility's customer service and performance levels.

The study phase of this project (Phase 1) was completed, and that work effort helped PWSA improve the customer service and performance levels by utilizing in-depth diagnostics of current operations. Veolia also developed recommendations for improvement that were approved by the PWSA board, and we are now supporting PWSA employees in implementing initiatives aimed at reaching new performance metrics. The Phase 1 report identified measures that will lead to annually recurring savings. During the partnership's first year, a team of water and wastewater experts from Veolia helped PWSA improve the utility's customer service and performance levels by conducting in-depth diagnostics of current operations, developing recommendations for improvement and supporting PWSA employees in implementing initiatives aimed at reaching new performance metrics. The analysis and resulting operational changes helped PWSA reduce its cost of operations and increase the utility's revenue by, among other things, re-securing a large commercial customer. The total impact of these changes has allowed the PWSA to approve an annual budget without a water rate increase.

Early quick-wins under Phase 1 work for this project involved optimizing water production run-times at the membrane plant, which will reduce chemical costs by $350,000 annually, and implementing enhancements at the customer service call center that slashed the call-abandonment rate almost immediately and reduced customer call waiting time by half. A key focus of the work is on identifying efficiencies in O&M practices for over $3 billion in above- and below-ground infrastructure that serves the water and sewer conveyance needs of customers across 54 square miles. The initial tasks in this area involved working with the PWSA's managers and staff to meet Consent Decree (CD) obligations to state and county regulators. Under this initiative, Veolia's management and support teams worked to organize the department and create a culture of responsibility and accountability for the success or failure of projects. Veolia also worked with the PWSA's local and national engineering consultants and contractors to get them back on schedule, clearing a backlog of potentially litigious disputes, which allowed projects to move forward. Other tasks included working on the feasibility of creating a stormwater authority to better assess stormwater usage and create additional revenue for increased levels of service. Additionally, Veolia assisted with the planning for a more than $150 million Capital Improvement Program (CIP) covering three years. This initial program addressed the PWSA's most critical infrastructure needs. The underground (water and sewer) pipelines in Pittsburgh are 80 to 100 years old and winter line breaks are a constant occurrence, so the PWSA is continually replacing underground assets.

Throughout these efforts, Veolia's Pittsburgh-based team worked side-by-side with the PWSA's staff, helping them execute the utility-approved initiatives and training them to sustain the work after the work of this partnership is complete.

- Client Reference: Alex Thomson, Chairman of the Board, PWSA c/o Houston Harbaugh, P.C. - Three Gateway Center, 401 Liberty Avenue, 22nd Floor, Pittsburgh, PA 15222 - Telephone: 412/281-5060 - Email: athomson@hh-law.com

- **City of Buffalo, New York** - In 2010, Veolia began a 10-year partnership with the City for O&M of their water supply system which serves more than 77,000 customer accounts. This is the largest water system under contract O&M in New York State, with facilities and operations that include: a 160-MGD surface water treatment plant; 814 miles of water distribution system, customer service management (meter reading, billing and collections); capital program management; and underground asset management (UGAM) and above-ground asset management programs.

"The Buffalo Water Board... is confident that we have selected the best operator for our system ... Veolia Water's demonstrated focus on service has convinced us that our long-term partnership will result in notable advances ... We expect Veolia Water to move us forward through the next decade with marked efficiency improvements and technological advances while maintaining our exceptional water quality."
– Oluwole McFoy, Chairperson, Buffalo Water Board
Speaking at the start of the contract in 2010.

In additional, Buffalo was one of the first cities in the U.S. to use the Veolia North American Meter Testing Facility. Under that approach, some 400 meters from the City have been sent to the facility on an annual basis for accuracy testing and evaluation of remaining life. On average, Veolia repairs/replaces more than 3,400 meters annually in Buffalo, and customer service metrics involve answering up to 7,000 calls a month in one minute or less and collecting 96% of meter revenue. Some 96% of all meters in the City are true-read type, with only 4% being estimated, and over 3,000 commercial and industrial accounts in Buffalo are now on mobile-read AMR systems.

Veolia transitioned the City's water operations to our firm under a delegated management type of contract, with the O&M staff remaining direct City employees working under supervision of Veolia's management team. Under this arrangement, Veolia has worked with the City and the staff to establish new work disciplines and procedures and to drive performance and enhance the quality of service. A core part of this effort involved establishing some 20 performance metrics to track and determine performance and accountability under this partnership.

In the area of customer service, Veolia implemented new customer service phone/information systems and partnered with the Water Authority service center staff to implement a process of a customer service cultural change that have enhanced performance and provided a better customer experience.

- Client Reference: O.J. McFoy, Water Board Chairperson, City of Buffalo, City Hall, 65 Niagara Street, Rm. 1101, Buffalo, NY 14202 - Telephone: 716/851-4333 - Email: omcfoy@sa.ci.buffalo.ny.us

- **Tampa Bay Water, Florida** - Veolia has worked with this agency since 2000 under multiple contracts that have focused on water treatment, storage and supply.

Tampa Bay Water, a regional water authority, serves the needs of over 2.5 million people in the communities of Tampa and St. Petersburg, and this agency ranks as the largest wholesale treated water supplier in Florida.

Veolia's initial project with Tampa Bay Water began in April 2000 when, following a year-long selection process among four competitive teams, they awarded our company a $135 million, 15-year (with a 5-year option) contract to design, build and then operate a new 60-MGD Regional Surface Water Treatment Facility.

Since that time, the Tampa Bay Water-Veolia Water Public-Private Partnership has constantly expanded over the years – a testament to the quality of our work and our client's trust and satisfaction.

Veolia's initial design-build-operated (DBO) contract was for a 66-MGD surface water treatment plant, and that was followed by additional service agreements for the maintenance of a 30-MGD groundwater treatment facility, O&M of a 15-billion reservoir, and an engineering-procurement-construction management (EPCM) type contract for a new 45-MGD hydrogen sulfide treatment plant and 20-MGD high-lift pumping station.

The Public-Private Partnership between Tampa Bay Water and Veolia Water, which began in 2000 and now encompasses multiple projects for the water treatment and supply, ranks as the largest and most successful of its type in the State of Florida. The project has been recognized with numerous awards, including the 2013 Plant Operations Excellence Award from the Florida Department of Environmental Protection.

Tampa Bay Water also awarded Veolia Water a second DBO contract to expand (nearly doubling the size) the original surface water plant from 66-MGD to 120-MGD.

Today the Public-Private Partnership between Tampa Bay Water and Veolia Water is the largest in Florida, and the surface water treatment plant is among the most technologically sophisticated in the world.

- Client Reference: Mr. Matt Jordan, General Manager, Tampa Bay Water - 2575 Enterprise Road, Clearwater, FL 33763 - Telephone: 727/796-2355 - Email: mjordan@tampabaywater.org.

- **DeKalb County Department of Watershed Management (DWM), Georgia** - DeKalb County is Georgia's third-largest county, with more than 700,000 residents. The DWM hired Veolia in 2014 to assist in identifying cost savings and customer service improvement, and work completed to date has involved conducting a comprehensive and independent review of their water and wastewater operations.

  DWM's operations include: a 140-MGD water treatment plant; 65 pump stations; two wastewater treatment plants (20-MGD and 36-MGD in capacity); more than 5,000 miles of water and sewer pipe; and a customer service operation that provides services to 700,000 residents in the Atlanta metropolitan region.

  The County and Veolia estimate that this review could produce as much as $8 million in savings annually for DeKalb ratepayers, reducing costs and helping mitigate rate increases.

  After a thorough analysis of existing operations, Veolia has presented a proposal to transform the entire customer service organization and leverage existing technological solutions to reduce wait times and increase satisfaction for customers. In addition to customer service, Veolia will support implementation of best practices across the utility's administration, planning, operations, maintenance and capital programs, and billing and collections.

  In tandem with the assessment, Veolia is working with the DWM to implement County-approved operations and management initiatives focused on achieving measurable operational, revenue and organizational enhancements to ultimately reduce operating costs and improve service levels, allowing DWM to provide more efficient and sustainable services.

  Some of the early wins under this contract have included: construction and maintenance wrench-time findings that offer the potential for more than $1 million in annual impacts; efficiency studies of field operations crews at the wastewater plant that identified more than $1 million in annual savings through in-sourcing current contractor spend; and more than $500,000 in annual savings identified in the areas of chemicals and power at the water treatment plant. Veolia continues to work with the County as we focus on shaping a long-term approach to meeting their needs.

  - Client Reference: Dr. James M. Chansler, P.E., Director DWM, DeKalb County - 1580 Roadhaven Drive, Stone Mountain, GA 30083 - Telephone: 770/621-7234 - Email: jmchansler@dekalbcountyga.gov

- **New York City, Department of Environmental Protection (DEP), New York** - Veolia began working with the DEP in 2011 to optimize their operations and help implement savings initiatives. New York City's water and wastewater operations that serve over 9 million people daily, delivering over 1 billion gallons of clean water and treating more than 1.3 billion gallons of wastewater per day. These operations include: 13 wastewater treatment plants; a new 290-MGD water treatment plant; 6,000 miles of sewers; and 7,400 of miles of distribution lines.

  The primary scope of this PPS program involved reviewing all aspects of this utility's operations to assess potential improvements in areas including: chemical use and pricing; labor productivity; inventory management; sludge process optimization; and overall O&M. Additionally, the project identified such enabling steps as public outreach, legislative initiatives and other processes for the implementation of recommendations.

  Veolia's final report for the Phase 1 work ultimately identified over 100 implementable measures for the City's consideration. Throughout the first phase of this innovative partnership, the City's employees worked alongside our project team under a joint management and governance structure to identify operational and organizational efficiencies. In order to capture "quick wins," our joint team identified and implemented several cost-saving initiatives within the first three months: chemical procurement modifications, for example, yielded million dollars in annual recurring savings.

  Under this approach, Veolia has identified opportunities that are expected to yield annually recurring financial benefits of more than $100 million by 2016, and, to date, over $90 million in savings and revenue enhancements have been reported by New York City's DEP. These benefits represented between 9% and 11% of the agency's $1.2 billion fiscal year 2012 budget.

  In June 2012, Veolia received notice to proceed with the official implementation phase, Phase 2, which involves implementing the approved recommendations of the assessment phase (Phase 1) under a four-year contract. To implement this phase of the project, we mobilized a world-class team to work with the City's staff in their offices and at their water and wastewater operations locations.

  Veolia's unique partnership, New York City's Operational Excellence (OpX) program, is focused on enhancing water and wastewater services, streamlining workflows, boosting efficiency and continuously identifying opportunities for improvements that will allow DEP to maintain its high level of customer service, safety and productivity while minimizing rate increases for its roughly 836,000 ratepayers. To achieve this, DEP set an ambitious goal for the OpX program right from the start – to achieve significant operating benefits by 2016. The program goes beyond individual projects and encompasses transformational initiatives, including enhancing performance management, strengthening core capabilities in human resources and procurement and fostering an organizational culture focused on performance and continual improvement. To reach these goals, the Veolia-led team worked with DEP to:

  - Review current O&M practices for potential improvements in terms of energy usage and production opportunities, chemical usage and pricing, labor productivity, inventory management and optimal sludge processes.
  - Recommend implementable measures to improve and/or streamline operations and maintenance, increase efficiencies, enhance productivity and reduce costs.
  - Support public outreach, legislative initiatives, and other processes required to implement recommendations.
  - Work with DEP staff to implement the recommended initiatives.

  During the top-down and bottom-up analysis work conducted in Phase 1, which continues in the Phase 2 work, the Veolia team identified current strengths within DEP's operation and noted five key areas where improvements will have significant financial benefits for the agency: efficient and sustainable use of resources and materials; enhanced workforce effectiveness; improved revenue collection; development of a metrics-based performance culture; and strengthening DEP's support services. The OpX program confirmed that DEP is a world leader in meeting drinking water and wastewater compliance, performing

well above the average of similar utilities. In the first six months of the OpX program, 100+ individual improvement ideas were identified and evaluated.

- Client Reference: Mr. Steve Lawitts, Chief Financial Officer, New York City DEP - 59-17 Junction Boulevard, 8th Floor, Flushing, NY 11373 - Telephone: 718/595-6576 - Email: slawitts@dep.nyc.gov.gov

- **City of Indianapolis, Indiana** - From 2002 to August 2011 (when the City completed the sale of its water system assets to a quasi-governmental utility services provider), Veolia operated what was (at the time) the largest water system O&M contract in the U.S. The Indianapolis water system is a regional operation, serving the needs of almost one million people in central Indiana, and included: four surface water treatment plants, ranging in size from 16-MGD to 96-MGD; five groundwater treatment plants, ranging in size from 2-MGD to 24-MGD; a 4,300-mile water distribution system; and pumps, storage tanks and reservoirs. The City's water system includes 38,000 fire hydrants, 300,000+ customer accounts, meter reading (310,000 meters – residential, commercial and fire), meter replacement program, and billing & collection (600,000 accounts). A key element of the project focused on customer service improvements, and over the nine years of work in managing this system (prior to the sale of the utility by the City), Veolia achieved a customer satisfaction rate of at least 90% (independent survey) and answering 88% of 70,000 monthly calls within 30 seconds. Improvements that were implemented by Veolia in the area of customer service includes empowering customer service employees to resolve most issues on the first call ("One and Done"); responding to 99% of emergency calls within 60 minutes; maintaining the operations ranking in the top quartile for performance in billing accuracy, customer complaints and O&M (AWWA benchmarking survey); ensuring customers were not without water for more than 12 hours; providing customers with 24-hour access to their billing and account information.

  Walk away with 29 mil

  Over the course of this nine-year contract, Veolia stopped a trend of substantial annual customer rate increases and had achieved a cumulative $83.1 million in savings at contract completion in 2011. At the end of the contract, our annual operating costs were some $2 million less than the previous management's had been when we started in 2002. We also improved the quality of operations by simultaneously achieving ISO 9001 and 14001 certifications, making the City the only major U.S. city to achieve both certifications.

  Veolia also worked with this client to establish a set of key performance indicators (KPIs) that formed the basis for the award of a portion of our fee. Under the incentive plan, a portion of our fees were paid only if we met specified customer service, water quality, operations and other performance measures. By directly linking performance to compensation, this partnership established a new model in the water outsourcing industry. Over the nine-year life of this agreement, Veolia achieved over 90% of incentive payment fees.

  - Client Reference: Mr. Sam Odle, Past Chairman, Board of Waterworks - City of Indianapolis, 3939 Priority Way S. Drive, #400, Indianapolis, IN 46220 - Telephone: 317/706-6349 - Email: samuallodle@gmail.com

- **Atlanta/Fulton County, Georgia** - Veolia, in a 50-50 joint venture with a minority-owned business enterprise, began operating the Atlanta-Fulton County Treatment Plant (which opened in November 1990). Over the term of this contract, Veolia has worked with the facility owner, the Atlanta/Fulton County Water Resources Commission (AFCWRC), to triple the capacity of this water treatment plant using a variety of process improvement and capital improvement approaches.

  The scope of work for this project has involved all aspects of facility O&M, as well as working with the AFCWRC for facility expansion and upgrade. Over the past decade, Veolia implemented a pilot program to increase the plant's 30-MGD production capability to meets its rated flow of 45-MGD (as rated by the Georgia Environmental Protection Division, GEPD), with no capital expenditures. Subsequent efforts increased the plant's rated capacity to 56-MGD; with an ultimate treatment capacity of 135-MGD. Water demand is so great that the AFCWRC began Phase II earlier than planned to upgrade the plant to 90 MGD. The plant has been running at this new flow capacity since March 1998.

  Veolia's O&M program has also reduced the power, chemicals, and overall operations costs, with savings passed on 100% to the AFCWRC. In addition, we have had no change orders to the contract even though the plant capacity expanded to 90 MGD under our current agreement.

The project also includes O&M responsibility for a 200-MGD raw water pumping station, dual 54-inch raw water pipe, more than 800 million gallons of reservoir capacity, and the treatment plant. The raw water pumping station—located on the Chattahoochee River—and raw water mains connect it to the surface water treatment plant. Major process equipment at the plant includes raw water traveling screens, grit removers, pumps, chemical addition/feed systems, meters, rapid-mix and flocculation chambers, declining-rate filters, clearwell storage, and finished-water pumps.

The success of the water operations project also led to a new contract with Fulton County for the O&M of their regional wastewater facilities, as highlighted above, and in 2014 Veolia was again selected for the renewal of the water operation contract under a competitive renewal process.

- Client Reference: Ms. Kathy Crews, General Manager - Atlanta-Fulton County Water Resources Commission - 9750 Spruill Road, Alpharetta, GA 30202 - Telephone: 678/942-2790 - Email: kcrews@afcwrc.com

- **District of Columbia Water and Sewer Authority (DC Water), Washington, DC** - DC Water is the largest wholesale customer of the Washington Aqueduct (Aqueduct), a federally-owned public water supplier operated by the U.S. Army Corps of Engineers. Veolia was retained to conduct a comprehensive evaluation of the Washington Aqueduct operations and related organization processes, and then recommend improvements that will add value to the delivery of services to its wholesale customers.

  Working in collaboration with Aqueduct staff, Veolia brought in experts to complete the evaluation phase (Phase 1), focused on identifying ways to ensure that DC Water is receiving reliable, quality drinking water at efficient production cost. More than 25 individual improvement ideas were identified and thoroughly evaluated during the four-month study phase, and up to 15% in savings were identified by the Veolia at the Aqueduct. The cumulative annual impact of successfully transforming operations is projected to be between $8 million and $12 million total (OPEX and CAPEX) recurring yearly saving.

  Veolia worked to review every aspect of the Aqueduct's operations, including the treatment process, maintenance and support functions. This review included the Aqueduct's capital program and also included an assessment of the key financial metrics and a high-level asset valuation.

  Additionally, our team worked to benchmark the Aqueduct operations against some of Veolia's own operations, as well as other publicly operated utilities in order to identify gaps in performance and efficiency. This comprehensive analysis work involved site visits to the treatment facilities, discussions with staff, hands-on observations of the work performed, and in-depth review and analysis of all of the documentation provided. For example, the maintenance assessment involved over 100 hours of wrench-time observations, and for the procurement scope, we reviewed all of the contract specifications, terms and conditions. As part of this work, our teams conducted over a dozen one-on-one discussions and workshops with leadership and staff.

  Veolia's team also analyzed data available across the organization and built new databases where necessary to generate insight. For instance, we used the CMMS data to develop the Pareto analysis in the maintenance section of the final report. To recommended implementable measures, Veolia facilitated workshops to generate, prioritize and refine initiatives across the different scope areas of the assessment. Most of the prioritization took place during the Steering Committee meetings, which included both Washington Aqueduct and DC Water participation and input. The Wholesale Customer Board was also involved in the review process through a presentation in September 2013 that summarized the primary findings and recommendations of the study. Working with the Washington Aqueduct and DC Water, Veolia identified approximately 10 improvement initiatives for maintenance, six initiatives in capital planning, five initiatives for water treatment, three initiatives for operations and two initiatives for support functions, including procurement. All of these more than 25 initiatives are supported by proposed enhancements in communications, training and performance management. These activities are often referred to as "enablers," which help organizations get the most out of their initiatives by properly supporting them with investments in these three overlapping activities.

Veolia has been selected to continue into Phase 2, Implementation, and that work (which will begin in 2015) will involve advising Aqueduct management and staff, coaching them on how to perform the recommended enhancements, measuring progress and refining approaches. The focus of this approach will be on ensuring that the staff can carry on this work and that the Washington Aqueduct can continue to benefit from our expertise long after our contract concludes.

- Client Reference: Thomas P. Jacobus, General Manager - Washington Aqueduct, Baltimore District, U.S. Army Corps of Engineers, 10 South Howard Street, Baltimore, MD 21201
  - Telephone: 202/764-0031 - Email: thomas.p.jacobus@usace.army.mil

- Staff Experience – Veolia has provided resumes for the two core staff proposed for this project as an attachment to this letter. These resumes provide the requested information on each staff member, including experience, relevant education, degrees, certifications and any other pertinent information related to the base of experience they bring to this partnership with the City of Flint.
- Project Scope – At the start of this letter we provided a statement discussing our firm's understanding of the requested services and our approach to providing the services requested.
- Price for Services – With our proposed approach, presented earlier in this letter, Veolia provide a pricing schedule (hourly rates for key staff) to perform the requested services.
- Affidavit – Veolia has completed the required Affidavit and it is provided as part of our submittal (as an attachment to this letter).

Finally, as we discussed at the start of this letter, Veolia is offering this as an Alternative Bid/Proposal, which is being submitted to you in the requested form and format – an executed original and two copies of our letter proposal submittal – and remains a valid offer for 120 days from the date of submittal. Further, our Bid/Proposal is based on the City's RFP and other documents and information provided as part of the procurement process, as well as on the contractual concepts under which Veolia normally provides the services outlined in this letter. Veolia's Bid/Proposal also assumes the negotiation and execution of a mutually acceptable contract consistent with those concepts. We would note that contractual provisions that often require discussion and further agreement include, among other provisions, warranties, indemnities, casualty risks, insurance, environmental liability, ownership of wastes, consequential damages, contractual limits of liability and remedies for breach or default and termination. We do not believe that these matters should present any serious obstacles to the negotiation of a contract, and we are prepared to meet with you to discuss them at your convenience.

As the Veolia Executive Sponsor for this proposed work with the City of Flint, I will be the key contact as we move forward with this process. Further, as we discussed in our meetings with you, my background for this key role includes a combination of utility management experience, as well as experience in leading Veolia's PPS work with other major communities and water utility operations in the U.S.

I am also the former President and Manager of the water system for the City of Indianapolis, which Veolia operated and managed for over nine years. Under that O&M contract, our firm achieved an industry-first in performance standards and quality management.

My contact information for the purposes of this Proposal is as follows:

Mr. David Gadis – Senior Vice President – Sales – Municipal and Commercial Development
Veolia Water North America Operating Services, LLC
101 West Washington Street, Suite 1400 East, Indianapolis, Indiana 46204
Telephone: 317/716-5683 – Fax: 317/917-3718 – Email: david.gadis@veolia.com

I invite you to contact me should you have any questions with regard to our Bid/Proposal, or if you need any additional information.

We very much look forward to your review of this submittal and the next steps in this procurement process for this proposed new partnership.

Sincerely yours,

David Gadis
Senior Vice President
Veolia Water North America Operating Services, LLC

Attachments:

1 - Resumes for Key Staff
2 - Experience Summary Table
3 - Affidavit for Corporation

Attachment 1

Resumes for Key Staff

VEOLIA

Marvin C. Gnagy, Jr., P.E.

VEOLIA

Education:

BS, Chemical and Environmental Engineering, University of Toledo

Registrations/ Certifications:

F-1 Waterworks Operator, Michigan

Registered Professional Engineer, Ohio

Class IV, Water Supply Operator, Ohio

Class III, Wastewater Operator, Ohio

Memberships/ Affiliations:

American Water Works Association

Operator Training Committee of Ohio (OTCO)

Background:

Mr. Gnagy is the Water Process Manager with the Engineering and Optimization group of Veolia Environnement North America (Veolia)'s Municipal and Commercial Technical Support Group. In this role he provides support for Veolia's design/build, design/build/operate (DBO) and operations, maintenance and management (O&M) projects in the U.S. and Canada. This includes providing technical and capital project support to municipal, commercial and other projects in the water and energy business lines.

Mr. Gnagy joined Veolia in 2010, and prior to his current role he worked as the Municipal Water Technical Manager with Veolia Water North America Operating Services, LLC (Veolia Water)'s Technical Direction Group. In these technical leadership roles, he has provided engineering and operational expertise to projects related to troubleshooting process and equipment problems, achieving water quality goals, maintaining regulatory compliance, optimizing treatment and chemical processes, maintaining system water quality and participating in the development of new projects throughout North America.

Mr. Gnagy has also worked as part of the teams engaged in the delivery of projects under Veolia Water's Peer Performance Solutions (PPS) project approach. This new approach involves working with large water and wastewater utilities in to conduct detailed operations evaluations that lead to operations efficiencies and cost saving for their operations. In this work, Mr. Gnagy has provided support for some of the largest water and wastewater utility operations in the U.S., including that for New York City, New York.

Mr. Gnagy has over 33 years of experience in management, operation, maintenance, design and construction of water treatment systems. He is experienced with chemical treatment operations and troubleshooting for the optimization of treatment processes and operational sequencing.

Mr. Gnagy also has experience in conventional and advanced treatment technologies, and has been involved with solving treatment issues and providing regulatory compliance. His experience includes: water supply development and monitoring; chemical treatment; mixing applications; taste and odor control; oxidation and coagulation treatment; chemical softening; ion exchange softening; clarification; filtration techniques; membrane filtration and membrane softening; disinfection methods; pumping operations; bench-scale, pilot testing and demonstration studies; high-rate treatment technologies; dewatering and solids handling; and process monitoring and optimization. His design experience has provided operator-friendly solutions to solve both regulatory and operational issues for a number of water treatment systems in the U.S.

In addition, Mr. Gnagy has specific knowledge of regulatory drivers and compliance in multiple state, and he has been involved with the development of site-specific operating strategies that help treatment plants achieve water quality goals and regulatory standards.

Work History:

- **2013-Present: Water Process Manager – Engineering and Optimization Group – Municipal and Commercial Technical Support Group – Veolia Environnement North America**
  - Works as part of an in-house specialty team that provides technical and management support for new and ongoing projects with municipal and commercial clients. This involves supporting projects under the water treatment and supply, wastewater collection and treatment, and energy utility operations and management business lines.
  - Served as Subject Matter Expert in the area of water operations for a contract with the Detroit Water and Sewerage Authority (DWSD) and the City of Detroit to evaluate their water and wastewater operations and proposed solutions. This includes an intensive due diligence examination of the facilities and operations and development of two reports, a Peer Review Report, which looked at the current operations with a focus on identifying immediate and long term needs for the DWSD, and a Transition Plan: Retail Services Report for the City. These reports outlined the issues facing the DWSD and the City as the water and wastewater operations changed under a new regionalization approach.
- **2010-2013: Municipal Water Technical Manager – Technical Direction Group - Veolia Water North America Operating Services, LLC**
  - Worked as part of the Veolia Water PPS team in New York City (operations evaluation and identification of improvements for the City's water supply systems), as well as the team involved in implementing a PPS project with DC Water and Sewer Authority (DC Water), Washington, DC. The DC Water project involved conducting an independent comprehensive review of the operations and management of the Washington Aqueduct (WAD). The focus of this work was on examining WAD's operations, considering: overall operational efficiency; reliability and security of supply; and total water quality management. The project with New York City involved operations efficiency studies that identified utility-approved opportunities expected to save the City $108–$130 million per year; Veolia Water is currently engaged in the implementation phase (Phase 2), which will cover the next five years.
  - Responsible for providing technical and operational expertise to current and ongoing Veolia Water projects. Participated in the development of new projects throughout North America.
  - Provided technical consultation and process troubleshooting for water treatment plant operations throughout the U.S., including a variety of conventional and advanced water treatment processes and the specialized equipment they employ.
- **2009-2010: Water Resources Manager - Brown and Caldwell**
- **2005-2009: Water Resources Manager/Operations Manager - URS Corporation**
- **1996-2005: Operations Specialist/Senior Design Engineer - Arcadis**
- **1989-1996: Operations Specialist - Jones & Henry Engineers**
- **1986-1989: Superintendent of Water - City of Defiance, Ohio**
- **1979-1986: Superintendent of Water - City of Berea, Ohio**
- **1977-1979: Water and Wastewater Operator - Village of LaGrange, Ohio**

Other Key Experience:

- Involved with the testing design and optimization of treatment processes including: source water characterization and oxidative organics fractioning; carbon adsorption; enhanced coagulation techniques; effective mixing applications; high-rate clarification processes; solids contact clarification; high pressure and low pressure membrane technologies including ultrafiltration (UF) and nanofiltration (NF); TOC removal and DBP control; enhanced softening techniques; anion exchange processes; chlorine and chlorine dioxide disinfection; chloramination; precipitative

softening and recarbonation; tube and plate settlers; sludge management (pumping and processing, gravity thickening, lagoon storage and dewatering, land application, filter press dewatering and centrifuge dewatering); and laboratory analyses and operations.

- Significant experience in distribution system operations, including pumping operations, booster disinfection techniques, water quality monitoring, taste and odor investigations, iron and manganese related issues, unidirectional flushing programs, cross connection control, and repair and maintenance of piping systems.
- Served as Project Manager for a number of water treatment plant design projects related to implementation of chemical and treatment process improvements aimed at achieving compliance with drinking water standards, and improving plant operations and water quality. Provided construction oversight for the projects once construction of the improvements began.
- Provided chemical and process optimization services for a number of water treatment plants across the U.S. defining needed upgrades in operating practices and/or process equipment to enhance water quality and reduce operating costs.
- Conducted a number of bench-scale, pilot-scale, and full-scale process investigations related to identification of operating strategies and advanced treatment technologies to meet more stringent drinking water standards and developed recommendations for process treatments and equipment necessary to achieve regulatory compliance.
- Designed and equipped municipal drinking water laboratories for process monitoring, bacteriological analyses, algae identification and speciation, and advanced instrumentation and analyses.
- Prepared site-specific water and wastewater treatment plant operations and maintenance manuals for more than 120 systems across the U.S. outlining operating strategies, equipment descriptions, process control techniques, instrumentation and control systems, troubleshooting, and maintenance activities.
- Developed operating standards and training manuals related to jar testing and coagulation operations, mixing applications, solids contact clarification, water and wastewater disinfection, lime-soda softening and recarbonation techniques, filter inspection techniques, formation and control of DBPs, and an overview of the Stage 2 D/DBP and LT2 ESWT Rules. Also served as principle instructor for these courses since their development.
- Instructor for basic and advanced water treatment courses for the Operator Training Committee of Ohio; and instructor for basic math, basic chemistry, and basic hydraulics for the Michigan Department of Environmental Quality.

Theping Chen, P.E.

VEOLIA

Education:

BS, Environmental Engineering, East China University of Chemical Technology, 1985

MS, Environmental Engineering, University of North Carolina at Chapel Hill, 1991

Registration:

Registered Professional Engineer, Michigan

Additional Training and Certification:

Construction Documentation Technologist

Memberships/ Affiliations:

American Water Works Association (Past National committee members on Source Water Protection, Taste & Odor, and Organic Contaminant Control)

Water Environment Federation

International Ozone Association

(Current PAG board of directors, and past conference planning committee),

International UV Association

Background:

Mr. Chen is a Process and Operations Optimization Manager with the Engineering and Optimization group of Veolia Environnement North America (Veolia)'s Municipal and Commercial Technical Support Group. In this role he provides support for Veolia's design/build, design/build/operate (DBO) and operations, maintenance and management (O&M) projects in the U.S. and Canada. This includes providing technical and capital project support to municipal, commercial and other projects in the water and energy business lines.

Mr. Chen has almost 30 years of water system engineering, operations and research experience. He joined Veolia in 2014 and has been engaged in supporting the delivery of projects under O&M and Peer Performance Solutions (PPS) project approaches. The PPS approach involves working with large water and wastewater utilities in to conduct detailed operations evaluations that lead to operations efficiencies and cost saving for their operations. In this work, Mr. Chen has provided support for some of the largest water and wastewater utility operations in the U.S., including that for New York City, New York, and Washington, DC. Most recently he was part of the Veolia team that worked with the Detroit Water & Sewerage Authority in conducting an operations assessment, which yielded a comprehensive due diligence report and a second future planning/operations report for a regional approach for the water and wastewater operations.

Mr. Chen's experience includes working as a Senior Technical Specialist, Senior Project Manager, Technical Manager, as well as Research and Development (R&D) Specialist. He has extensive experience in water, wastewater treatment and water quality, and has worked on numerous study, planning, design, and services during construction projects. This work has included master planning, water and wastewater treatment, taste and odor control, asset management, biosolids management, residual management, and water quality.

Work History:

- **2014-Present: Process and Operations Optimization Manager – Engineering and Optimization Group – Municipal and Commercial Technical Support Group – Veolia Environnement North America**
  - Works as part of an in-house specialty team that provides technical and management support for new and ongoing projects with municipal and commercial clients. This involves supporting projects under the water treatment and supply, wastewater collection and treatment, and energy utility operations and management.
  - Served as a Technical Support Manager for PPS and O&M project sites, including:
    - DC Water and Sewer Authority (DC Water), Washington, DC. - Project involved conducting an independent comprehensive review of the operations and management of the Washington Aqueduct (WAD). The focus of this work was on examining WAD's operations, considering: overall operational efficiency; reliability and security of supply; and total water quality management.

Under the DC Water PPS project task, a key work task included: conducting a workshop evaluating the induction mixer to improve rapid mixing, review of water quality and chemical dosages, alternatives for controlling algae in the two water treatment plants) for the Washington Aqueduct McMillan Water Treatment Plant.

- Pittsburgh Water & Sewer Authority (PWSA), Pennsylvania – This PPS project has involved evaluating the operations of this agency's water and wastewater operations. This utility serves more than 300,000 people in the greater Pittsburgh area. A main area of focus for the work was on the development of Key Performance Indicators (KPIs) that were used to drive system improvements for the PWSA. Work tasks engaged in under this contract involved evaluating the algaecide alternative, and CAL-FLO replacing lime.
- Detroit Water & Sewerage Department, Michigan – Served as part of a team that worked with the DWSD along with Counties in the greater Detroit area in shaping comprehensive water and wastewater solutions considering the needs of the City and those of customers in the surrounding County areas. The work involved developing a comprehensive Peer Review Report, along with a second report (Retail Report) that discussed issues surrounding the formation of the Great Lakes Water Authority and the impact of that on operations of the DWSD and the City of Detroit. These reports involved performing extensive due diligence of the City's water and wastewater assets, preparing reports documents and supporting materials, and then presentations to multiple parties, including state level and judicial, City and County managers. Work tasks under that contract included conducting a process review for the DWSD's five water treatment plants.
- City of Buffalo, New York – This is an O&M contract that began in 2010 for operations and management of a water system serving a population of 280,000, with facilities and operations that include: a 160-MGD surface water treatment plant; 814 miles of water distribution system, customer service management (meter reading, billing and collections); capital program management; and underground asset management (UGAM) and above-ground asset management programs. Involved in supporting this operation in soliciting bids for an induction mixer and streaming current monitor, and alternative evaluations for these systems.
- City of Brockton, Massachusetts – This is an O&M contract that began in 1988 and includes: water operations for a 1.3-MGD and a 24-MGD surface water treatment plant, two raw water pump stations (40-MGD capacity), and two ground storage tanks (11.4 million gallons capacity); and wastewater operations for a 20.49-MGD tertiary wastewater treatment plant, three pump stations, and an 18 dry ton per day multiple-hearth sludge incinerator. Served as the Lead Technical Support Specialist for the conduct of a comprehensive water quality and water treatment plant review. This included evaluating alternatives for algae control, TOC and manganese removal, and evaluating manganese removal and short filter runtime, as well as backwash pump cavitation issues.
- Owned and Managed Energy Operations – Conducted a comprehensive system operation and optimization review for two Veolia energy makeup water treatment plants, including: Kendall Station Cogeneration in Cambridge, Massachusetts and the Grays Ferry Cogeneration Plant in Philadelphia, Pennsylvania. This included performing a review of river source water pretreatment alternatives, and identifying optimization opportunities of the ultrapure water treatment processes.

- **2013-2014: Independent Water Consultant – Solon, Ohio**
- **2012-2013: Project Principal - ARCADIS US Water – Cleveland, Ohio**
  - Served as Task Lead for softening water treatment plant upgrade and expansion evaluation for:
    - Dayton and Montgomery County Water Efficiency Master Plan, Ohio- Worked as the senior consultant and lead author of the three tasks reports, including: Task 5 - Water Treatment Plant Capacity Evaluation and Assessment for two 96-MGD softening water treatment plants; Task 6

– Regulatory Review and Compliance Assessment; and Task 9 – Evaluation of Groundwater Wells Reclassification's Impact on Water Treatment.

- Delaware County Water System Master Plan, Ohio – Served as the Task Lead for water treatment. The work involved evaluating the historical water productions and forecasted the future water production profile. Evaluated the treatment plant expansion and upgrade needs for four surface water and groundwater softening plants to best utilize the available source of supply to meet the future water supply needs. Provided recommended scope of work, process schematic and opinion of cost for upgrading and expanding the water treatment plants.
- Northeast Ohio Regional Sewer District (NEORSD) - Cleveland, Ohio – Worked as a Technical Consultant/ O&M Manual Task Process Engineer for the NEORSD's Southerly Wastewater Treatment Plan's biosolids handling facility. Responsible for preparing an O&M manual for the centrifuge dewatering system.
- Eureka Resources, Pennsylvania - Served as Process Mechanical Design Task Leader for a new frac wastewater treatment plant. The process included: oil/water separators; primary clarifiers; pH adjustment units; membrane biological reactors; crystallizer; sludge thickening and dewatering units; and various raw wastewater and treated wastewater storage tanks. Lead the design documentation preparations and coordinated and reviewed the P&ID drawing development.
- New York City, Department of Environmental Protection, New York - Performed a quality assurance and quality control (QA/QC) role for the NYDEP's Groundwater Treatment BOD report. Reviewed basis of design report for treatment of three well sites which uses treatment processes such as air stripping with and without vapor GAC adsorption, liquid GAC adsorption, and chemical oxidation followed by filtration for iron and manganese removal.
- City of Monroe, Michigan – Served as the Technical Lead for the City's Water Treatment Plant Ozone System Improvement Study. Assessed the current conditions of the existing system, evaluated different generator and ozone contactor improvement alternatives, and made recommendations and provided opinion of cost for each alternative.
- Other Work - Supported winning proposals for Akron Water Quality Modeling, Alliance Joint Dewatering System, and Minneapolis Water Pool of Consultants. Served as: Technical Knowledge and Innovation and Technical Community of Practice member; Client Account Manager for Aqua Ohio and Pennsylvania American Water; and manager and support specialist for business development efforts, including pursuits with DWSD, NEORSD, the Louisville Water Company, the City of St. Louis, the MSD, the City of Toronto's wastewater treatment plant, the City of Ann Arbor's water treatment plant, the City of Toledo's water treatment, and the Warren County water treatment plant.

- **2012: Technical Director and Technical Practice Network Leader, Water and Urban Development - AECOM Asia - Hong Kong/Shanghai China**
  - Served as the Technical Practice Network Leader and the Team Leader for: Asian Development Bank/JiangXi Government Boyang Lake Water Resource Management project; Project Manager of Shanghai Wastewater Treatment Plant Sludge Management Strategy Optimization Study; and Process Lead for the 50-MGD first membrane filtration plant feasibility study, and first 37-MGD sea water desalination plant feasibility study proposal in Hong Kong.
- **2010-2012: Regional Director, Water and Urban Development - AECOM China – Shanghai**
  - Served as the Regional Director for Water and Urban Development in China with responsibility for: operation, strategic plan development, client management, business development and project delivery and staffing management of PRC WUD business line; leading the team winning record numbers of ADB and WB funded PPTA, ADTA and loan implementation projects (over $10M USD) in 12 months; conducting high profile national strategy and policy projects in China on Boyang Lake

Water Resource Management (largest fresh water lake in PRC), National Stormwater Management and Water Logging Prevention Policy Study, and National Wastewater Treatment Plant Sludge and Wastewater Reuse Technology and Policy Study for PRC; consulting on wastewater treatment plant sludge management technical route studies for Beijing and Shanghai, two largest municipalities in PRC, including two of world's largest wastewater treatment plants: the Beijing GaoBeiDian plant and the Shanghai BeiLongGang plant; and serving as Process Manager for the Hong Kong Shatin Water Treatment Plant reprovisioning (expansion from 90-MGD to 145-MGD) with ozone and two-stage filtration (one biological) treatment processes.

- **2010: Senior Project Manager/Senior Technical Specialist - AECOM - San Francisco, California**
  - Worked as Senior Project Manager supporting AECOM Water operations and projects in North America. This included:
    - Project Manager and Lead Process Engineer on the Groundwater Reuse project for NASA Ames Research Center in Moffat Field, California. Upgraded the collection system from three pump-and-treat groundwater treatment systems, conducted hydraulic analysis and designed the pump and control upgrades. Designed the modifications of converting the existing 240,000 gallon tank into a RO permeate storage tank. Lead the alternative evaluation, and design services for treating the three different sources of pump-and-treated groundwater. Prepared the D/B contract for construction of a new 850,000 gallon tank. Designed the upgrade to the RO pretreatment system including the installation of dual media filter, UV reactor, and chemical feed system. Designed the refurbishment of the RO system including the new pumps, sensors, and RO membrane elements. Designed the new CIP system, and CIP waste neutralization and disposal system and piping, RO concentrate disposal system and piping. Designed and upgraded the control system for the RO permeate distribution system, provided the constant pressure in the system that allows the auto-source switching in the event the distribution system loss of pressure.
    - Engineering Manager for a multi-year, as-needed, system-wide zebra mussel study and control project with the California Department of Water Resource.
    - Senior Technical Consultant on the City of Portland, Oregon's, 225-MGD Bull Run Water Treatment Plant Chlorination Alternative Study. Evaluated bulk hypochlorite storage and feed, low strength (0.8% wt.) onsite generation of hypochlorite, high strength (12% wt.) onsite generation of hypochlorite, and onsite gas chlorine generation technologies. Conducted the conceptual design, including sizing, layout, list of equipment, construction and O&M cost estimate. Conducted the market research on installations, operation experience and cost.
- **2006-2009: Global Drinking Water Oxidation & Disinfection Technical Practice Workgroup Leader, Project Manager and Senior Technical Specialist – Metcalf & Eddy, Inc. (later acquired by AECOM) – Cleveland, Ohio**
  - Served in multiple roles for an engineering and operations company, including serving as: Global Drinking Water Oxidation and Disinfection Technical Workgroup Leader; International Ozone Association Champion; Ohio American Water Company (OAWC) Client Coordinator; Senior Technical Specialist; and Project Manager.
  - Key project work and accomplishments included: developing the company's first project for from both Ohio American Water and Pennsylvania American Water, and then managing the treatment plant projects with these two clients; developed the $25 million Ashtabula Water Treatment Plant design/build project with the OAWC; organized the workshop for IO3A and IUVA/IO3A conferences; served as Project Manager and Lead Process Engineer for the OAWC Marion Water Treatment Plant chemical and filter systems improvements project; served as Project Manager for the OAWC Marion Water Treatment Plant needs assessment study, and on-call engineering services for both water and wastewater systems; served as Project Manager for the Elyria Water Treatment Plant intake study and preliminary design project; served as the Lead Technical

Engineer on the Shreveport ozone system improvement study and preliminary design project; served as the Lead Technical Engineer on Miami-Dade County Water and Sewer Department's Hialeah Water Treatment Plant filter backwash improvement alternative evaluations; served as the Project Manager and Lead Process Engineer for the Pennsylvania New Castle water treatment plant filter-to-waste addition project; and Project Engineer for the Northeast Ohio Regional Sewer District's ECT-4 Baffled Drop CSO Shaft Physical Model Study.

- **2001-2006: Multiple Technical and Management Roles - CH2M HILL – Detroit, Michigan**
  - Worked in multiple roles, including: Northeast Regional Water Process Practice Leader; Northeast Regional Water Treatment Technology Leader; member of the Detroit Client Service Management Team; Member of the Northeast Regional Water Service Team; Technical Director of China Water Business Group; and Project Manager.
  - Responsibilities in these roles included: contributing to developing strategic business plan for local, and region-wide markets; maintaining client contact and involvement in business development efforts for strategic water projects; and contributing to business development for water projects in Ann Arbor, Louisville, Cincinnati and other communities in the Mid-West.
  - Worked on multiple projects with the DWSD, including:
    - Task Manager for DWSD's 50-year Comprehensive Water Master Plan. This work involved: evaluation of capacity development; analysis and projection of significant industrial flows and loadings; and projected flows from significant industrial users (SIU) and quality in the next 50 years by decade, industrial category, and geographic areas, within DWSD's service area.
    - Task Project Manager for the summary and evaluation of Detroit wastewater treatment plant capacity and performance, as part of the development of a comprehensive wastewater master plan for the DWSD. The plant has a rated secondary treatment capacity of 890-MGD, and primary treatment capacity of 1,700-MGD. Summarized the design criteria; assessed the existing and near-term capacity under the comprehensive treatment plant renovation project for both liquid and solids processing streams; conducted water quality and compliance status analysis; and discussed the suitability of the plant to meet future expansion and treatment needs including the proposed additional dewatering from CSO basins.
    - Project Manager and Lead Process Engineer for improvements to two wastewater treatment plant pump stations, including pickle liquor buildings, the polymer utilization building, and main plant influent building rehabilitation for DWSD. The wastewater treatment plant has a secondary treatment capacity of 890-MGD. Replaced all polymer delivery pumps, pickle liquor feed and transfer pumps, and influent sampling pumps. Managed the selection and sizing of various chemical and wastewater transfer pumps, with specific consideration of handling chemicals and high solids applications, and designed the new piping layout and control system. Assisted in preparing the specifications for various pumps and pipes and oversaw the design and specification of the basket strainers. Prepared construction documents and provided services during construction.
    - Managed an evaluation of long-term solids disposal alternatives as part of the development of a comprehensive wastewater master plan for DWSD. The plant has a rated secondary treatment capacity of 890-MGD. Conducted a thorough review of the current solids production and handling practices at the plant; reviewed the applicable treatment technologies and current and future regulations; and developed various alternatives and implementation plans as well as a scoring system to rank and select the recommended alternatives. Also developed capital and operations cost estimates for each alternative.
    - Project Manager and Lead Engineer for field sampling activities review and pre-audit service for the DWSD. Reviewed program documents and QA/QC procedures as well as the standard operating procedures. Audited the field sampling safety issues, reviewed EPA auditing reports

and pertinent federal regulations and EPA guidelines, and recommended areas that needed improvement.

- Manage and Lead Engineer for the preparation of a low-interest loan application for the Drinking Water State Revolving Fund for the DWSD. Prepared an overview project plan for the 2004-2008 loan programs, successfully securing $30M per year in low-interest loans from the Michigan DWSRF.
- Task Manager for a source water protection project for DWSD. Summarized the pertinent federal and state regulations and international charters and agreements related to the Great Lakes and reviewed the associated watershed initiatives, trends, and programs, as well as the current and future monitoring technologies. Investigated the existing spill notification system and procedures and conducted a national survey on the early-warning monitoring and source water protection programs. Developed the framework for establishing a source water protection program. Made recommendations for short-, intermediate-, and long-term improvement and proposed the scope and estimated cost of the near-term capital improvement project needs of this first source water protection plan for a surface water utility in Michigan.
- Task Manager for the development of a water quality management and treatment plant capital improvement plan for DWSD, covering their five water treatment plants (with a combined capacity of over 1.7 billion gallons per day. Reviewed the past and ongoing projects, reviewed the short-term and long-term water quality regulations. Developed short- and long-term water quality goals. Conducted a thorough assessment and evaluation of the current treatment process for capacity, technology and performance. Selected future treatment technologies and prepared the conceptual preliminary design and cost estimate for each plant, including ozone and UV installations. Coordinated ongoing plant improvement projects and developed a capital improvement plan for plants that would meet both system growth and water quality needs while maintaining a limited increase (6-7 percent) of water rate to DWSD customers in the future.
- Task Manager for the development of DWSD's Wastewater Master Plan, which addressed: Significant Industrial Flows, Capacity and Performance Evaluation of the Detroit Wastewater Treatment Plant, Wholesale User Survey, and Long Term Solids Disposal Plan tasks.
- Managed the development of a customer survey and service plan for the DWSD. Designed the survey form and managed the design and distribution of the survey questionnaires.
- Project Engineer for the update of DWSD's industrial pretreatment program local limits database, including modification of the program and local limits calculation.
- Project Engineer for Phase I and project manager for Phase II of an atmospheric deposition study for the DWSD, addressing the air deposition addition of mercury, cadmium, and PCBs loads to the headworks of a wastewater treatment system. Developed a quality assurance project performance plan and field sampling standard operating procedures, and coordinated the lab SOPs. Managed the water-phase sampling and led data analysis. Interfaced with subcontractors and labs; conducted detailed chronicle and statistical data analysis of pollutant concentrations, fluxes, or loadings for dry deposition, wet deposition, runoff, ambient, and treatment plant influent and effluent. Developed several approaches in estimating the quantitative relationships between the air deposition and runoff, air deposition and the plant headworks loadings of PCBs, mercury, and cadmium. Prepared responses to the steering committee's review comments. Conducted all data treatment and prepared the final study report, providing the crucial information for the state to establish the regulatory policies toward these chemicals.

- Served as Senior Technical Consultant and Lead Engineer for a brackish groundwater treatment pilot study and preliminary design of the reverse osmosis water treatment plant at Moron Air Force Base in Spain. Led the technical evaluation and process design for providing portable water

to the base by evaluating, piloting, and designing a 1-mgd groundwater treatment facility. Conducted the desktop evaluation for alternative technologies to remove hardness, nitrate, TCE, and salinity from the groundwater sources. Developed the test plan and conducted the pilot tests on GAC, ion-exchange demineralizer, and reverse osmosis processes. Provided air-stripping unit troubleshooting, scale control evaluation, and preliminary design. Evaluated concentrate disposal alternatives and developed the construction cost estimate.

- Served as the Project Manager and Lead Process Engineer for the evaluation and design of an ozone system to remove geosmin-caused drinking water tastes and odors from the Lucerne Water Treatment Plant for the California-American Water Company. Evaluated the bench treatability data, designed the ozone and ozone/H_2O_2 application dose, and established the remaining ozone system design criteria, including a construction cost estimate. Prepared preliminary design of the system and evaluated different types of ozone generators, ozone dissolution methods, and ozone contactors. Determined final design, which included a LOX-feed ozone generator with side-stream injection skid and a pipeline contactor with the options of using an ozone contactor for disinfection (ozone alone) and taste and odor removal (ozone/H_2O_2) or T&O removal only.
- Served as the Lead Process Engineer for construction and start-up of the 17-MGD Windsor Water Treatment Plant's new ozone system. The scope includes the construction management, start-up of the ozone system, optimization of the ozone residual analyzer layout and design and upgrade of the ozone-quenching agent with calcium thiosulfate to increase quenching capacity and safety. Participated in the resizing of the tanks and redesign of the layout and spill containment area. Participated in process and start-up troubleshooting, including how to achieve the desired log inactivation of Cryptosporidium and residual quenching during winter season.
- Served as a Senior Consultant for ozonation design for the 167-MGD Tacoma, Washington, water treatment plant. Developed design criteria and evaluated bench testing results on geosmin and MIB removals. Employed the experimental design approach. Conducted statistical analysis of the experimental data, summarized the findings and conclusions of the tests, and prepared the study report.
- Served as Senior Consultant for an algal toxin removal project for the American Water Works Research Foundation (AWWARF). Prepared the testing plan using statistical experimental design methodology for ozone oxidation, UV/H_2O_2 oxidation, and PAC adsorption of the microcystin-LR. Conducted a statistical analysis on the testing results and prepared the study reports.
- Managed and served as Lead Technologist for a filter backwash and recycle stream evaluation and improvement study for the 27-MGD water treatment plant in the City of Ann Arbor, Michigan. Investigated the filter backwash and other recycle stream practices, as well as the average and peak instantaneous flow of each stream, and evaluated the potential hydraulic and water quality impact to the treatment process. Facilitated a plant staff workshop to develop operational and process improvements. Prepared report to submit to the Michigan Department of Environmental Quality.
- Served as Process Engineer for the development of a master water plan for the City of Ann Arbor, Michigan. Led a water treatment plant process criteria evaluation and evaluations of the treatment of 1,4-dioxane from the groundwater.

- **1992-2001: Multiple Technical and Management Roles - TETRA TECH MPS - Detroit and Ann Arbor, Michigan**
  - Worked as Project Manager, Senior Project Engineer, Project Engineer; and Water/Wastewater Technology Council Member.
  - Served as Process and Project Engineer for the Baby Creek combined sewer overflow control study for DWSD. Conducted a literature review, provided dry and wet weather multi-stage sampling of the CSO events, and performed bench-scale evaluations of various disinfection options, including UV, ozone, sodium hypochlorite, peracetic acids, and sodium bromide with sodium hypochlorite.

Proposed recommendations and disinfection design criteria. Prepared the disinfection study report and reviewed the final design study report.

- Served as Lead Engineer for a drinking water taste-and-odor study for DWSD, which received the 1998 Research and Technical Practices Award from the Michigan Section of the AWWA and required the development of monitoring and experimental plans and analytical standard operating procedures. Trained senior chemists to become flavor panelists, coordinated the monitoring efforts and flavor profile analysis, interfaced with clients, and conducted comprehensive powdered activated carbon and ozonation treatability studies to remove the taste- and odor-causing compounds from the water. Investigated a broad range of operational parameters and identified their impact to the odorant removals. Developed mathematical models for quantitative assessment of operational parameters and performance prediction.
- Served as Project Manager and Lead Engineer in the development of ozonation design criteria for taste and odor control and Cryptosporidium inactivation for DWSD. Conducted an ozone demand and decay study, and developed the design criteria for meeting the requirement of disinfecting Giardia and Cryptosporidium. Assessed the impact of the proposed treatment technologies on the current operation. Prepared the progress and final study reports and made presentations to the client.
- Served as Lead Engineer examining powdered activated carbon and chlorine interaction impact on T&O compound removal and contact time value for DWSD. Performed CT calculations under various conditions for four water treatment plants and made design and operational recommendations.
- Served as Process Engineer for an implementation assessment of PAC storage, dosing, and delivery facilities at four water treatment plants for DWSD. Developed the design criteria for upgrading the powdered activated carbon dosing systems and reviewed the conceptual design and cost estimate of the PAC feeding system. Also provided an engineering feasibility valuation of building centralized PAC storage and dosing facilities. Reviewed the contact time calculations under various PAC addition points for the four plants and developed design criteria for alternative PAC dosing systems.
- Served as Process Engineer for a backwash and residual management improvement project for DWSD. Developed the treatment process basis of design criteria and conceptual design for handling the backwash water and plant treatment residual for four water treatment plants with a combined capacity over 1,600-MGD. Conducted the historical data analysis and scenario analysis for determining the optimum equalization volume and treatment process design capacities.
- Served as a Co-principal Investigator which involved conducting an investigation for a taste-and-odor materials evaluation workshop for the American Water Works Research Foundation. Convened an international expert panel to develop a new AWWA drinking water standard for testing materials from taste and odor perspectives. Organized a workshop, managed literature review, and prepared the final standard and project report.
- Served as Resident Project Engineer for a seven-month pilot study to treat the low-strength, organics-containing cooling water for the Upjohn Company in Kalamazoo, Michigan. Participated in the planning, initiation, and operation of a 30-gpm carbon fluidized bed biological reactor. Coordinated with the client, vendor, and project manager and prepared weekly and final project reports.
- Served as Field Project Engineer for a three-month feasibility study for the Kellogg Company of Battle Creek, Michigan, for the treatment of high-strength BOD/COD cereal-production wastewater using a pilot upflow anaerobic sludge blanket bioreactor. Obtained optimum operation and design conditions and addressed typical operation interference such as shock loads of BOD and TSS.

- Served as Project Engineer for Michigan's Rouge River CSO control study for a national wet weather demonstration project. Trained the sampling crew, developed the field sampling SOPs, and coordinated with the weather service. Conducted detailed data analyses, such as concentration and load profiles for different pollutants, removal efficiencies, and overflow discharge quality. Drafted final report and provided recommendations for sampling and design of the future CSO basins.
- Served as Project Engineer for Michigan's Rouge River settling column study, as part of a CSO control study for a national wet weather demonstration project. Developed the experimental and sampling plans, trained technicians, performed data analysis, and drafted the report.
- Assisted in the evaluation of CSO control technologies and performance of retention basins in the Rouge River watershed. Assisted in evaluating the retention basin's effectiveness in disinfecting and removing numerous pollutants. Reviewed existing column testing protocol and proposed new protocol using modified columns and Imhoff cones. Developed a protocol for evaluating disinfection and the standard data analysis procedures to be used at all basins within the Rouge watersheds. Reviewed the mathematical models (steady-state settling model, statistical models, and dynamic models) available for predicting the basin long-term performance and individual event performance and assessed their advantages and limitations. Worked with modeling experts to develop new dynamic models for the project and developed the protocol for disinfection evaluation.

- 1991-1992: Process and Environmental Engineer (Biotech scale-up and Groundwater remediation projects) - ARCTECH, Inc. - Alexandria, Virginia
- 1988-1991: Research Assistant and Graduate Student (Thesis: Enzymatic Oxidation of Phenolic Pollutants) – University of North Carolina at Chapel Hill, Department of Environmental Engineering – Chapel Hill, North Carolina
- 1985-1988: Research & Design Engineer (industrial wastewater treatment) and Teaching Assistant – East China University of Chemical Technology, Department of Environmental Engineering and Institute of Chemical Environmental Engineering

Publications:

- Completed numerous technical articles, reports and other publications on topics related to water and wastewater treatment, water quality and research and development related topics.

David L. Gadis

VEOLIA

Education:

BA, Marketing/ Communications, Southern Methodist University (1984)

Memberships/ Affiliations:

Indianapolis Urban League

Indianapolis Sports Corporation President's Council

Indiana Business Diversity Council

Purdue University Science Bound

St. Mary's Child Development Center

Big Ten Basketball Tournament Committee

American Water Works Association (AWWA)

Awards:

Indiana Basketball Hall of Fame

2005 Achievement in Business Award, Center for Leadership and Development

2006 Sam Jones Award, Indianapolis Black Chamber of Commerce

Background:

Mr. Gadis is Vice President and Manager for Sales with the Municipal and Commercial Group of Veolia in North America. In this role he leads a team that is responsible for new project development and the support of ongoing projects and client relationships. This work has included supporting alternative project delivery approaches to municipal clients in the North American market. His recent work has focused on working with Veolia's team at the City of Detroit, Michigan, to support the identification of utility needs and solutions/approaches to address the City's water and wastewater utility.

Mr. Gadis was also a part of the Veolia team that working with the New York City Water Board and New York City Department of Environmental Protection (DEP) under the Operational Excellence (OpX) program. This team is charged with examining water and wastewater operations in the City with the goal of developing recommendations to streamline workflows, boost productivity, identify opportunities for efficiency gains, and keep future water rate increases as low as possible.

Prior to his current role, Mr. Gadis was the President of Veolia Water Indianapolis, LLC, the company that was charged with managing the water system providing service to almost a million in Central Indiana. The scope of this contract involved operating, maintaining and managing a water treatment, storage and supply system, a customer service organization responsible for meter reading for some 310,000 connections for the City of Indianapolis and an additional 15,000 connections through contracts with surrounding communities, as well as billing and revenue collection for 600,000 accounts. The contract also included a capital project component, and Veolia Water managed and implemented in excess of $200 million in capital work to improve the City's aging water infrastructure.

Prior to that, Mr. Gadis managed the procurement and operations of the Indianapolis Water operations, with responsibility for administering the Veolia Water Indianapolis minority-owned (MBE), woman-owned (WBE) and other locally-owned business involvement efforts. The success of this was demonstrated in the company's unmatched success in achieving local involvement in all aspects of the project work at levels that well exceeded all of the City's goals and expectations-- keeping 92% of the dollars spent in the local economy and maintaining a 35% M/WBE participation level. He also provided leadership for Veolia Water's local involvement program in Indianapolis, with involvement in numerous community service organizations in the community. Additionally, Mr. Gadis has played a key role in shaping Veolia Water's national program for MBE/WBE recruitment and involvement in governmental and industrial projects at sites across North America.

Mr. Gadis has over 23 years of overall business experience, with more than 14 years of management experience, and his involvement with the Indianapolis water facilities began back in 1998, working as the Director of Procurement for Indianapolis Water Company. He joined Veolia Water Indianapolis in 2002 on the transition of the water facilities.

Key Experience:

- **2013-President: Vice President and Manager – Sales – Municipal & Commercial Group - Veolia North America – Indianapolis, Indiana**
  - Provides leadership for a Sale team and new project development for Veolia's water and energy utility services line in North America.
  - Work has included the development and support for projects under Veolia's Peer Performance Solutions (PPS) approach, including a new project with the DeKalb County, Georgia, Department of Watershed Management (DWM). This work is focused on helping the County identify cost savings and help improve customer service by conducting a comprehensive and independent review of their water and wastewater operations. DWM provides services to 700,000 residents in the Atlanta metropolitan region through its system of water treatment and distribution, customer service, and wastewater collection and treatment.
- **2010-2013: Vice President – Municipal Sales Group – Veolia Water North America Operating Services, LLC – Indianapolis, Indiana**
  - Provided leadership for the company's sales and development program that has focused on identifying and developing innovative utility operations solutions for major cities in the U.S.
  - Worked as a part of the Veolia Water team for the Operational Excellence (OpX) program with New York City. The work is divided into two phases, with the Veolia Water Team first conducting an initial evaluation and recommendation phase that will result in a final report in 2012 of recommendations on how DEP can improve productivity and reduce costs. Based on that report, DEP has the ability to accept or reject any of the proposed operational changes and cost-saving measures. Improvements that DEP chooses will be implemented over a four-year period.
- **2008-2010: President – Veolia Water Indianapolis, LLC - Indianapolis, Indiana**
  - Served as the Executive officer for Veolia Water's operations of the City's water systems, under a project that was completed in 2011.
  - Served as a part of the transition management team responsible for managing the transfer of the water operations (owned by the City) to a new owner and operator. The sale of the City's water treatment and supply assets, which serve almost 1 million people in the region, was completed in 2010, and the transition of services was completed in August 2011. The key challenges of that process involved maintaining the levels of service and quality for the customers that rely on the water system, and providing ongoing operations, maintenance and management services as the new owner is allowed to implement its own operations and management approach.
- **2003-2008: Vice President and Chief Operating Officer – Veolia Water Indianapolis, LLC - Indianapolis, Indiana**
  - Responsible for day-to-day operations of the company, including field services, production, engineering, construction, procurement, risk management, asset management, laboratory services, health and safety, security, IOS9001 and 14001, as well as the company's MBE/WBE program.
- **2002-2003: Vice President of Shared Services – Veolia Water Indianapolis, LLC - Indianapolis, Indiana**
  - Responsible for procurement, fleet, risk management, warehousing, health and safety, security, and M/WBE development.
- **2000-2002: Vice President – Water Materials Unlimited (Indianapolis Water Company subsidiary) – Indianapolis, Indiana**
- **1998-2000: Director of Procurement - Indianapolis Water Company - Indianapolis, Indiana**

- Acted as Director of Supply Chain Management, with responsibility for a $15 million budget, $8 million in sales, non-regulated business development, and $7.5 million minority vendor program.
- Responsible for liability and property insurance claims, developing and administering the company's risk goals and objectives, and overseeing the procurement of goods and services.

- **1995-1998: Vice President – Monroe Guaranty Insurance – Indianapolis, Indiana**
  - Responsible for claims management, including $125 million of claims expenses.
- **1989-1995: Midwest Regional Manager – USF&G Insurance Company – Indianapolis, Indiana**
  - Managed 16 branch office operations, 120 employees and $200 million in written premiums. Responsible for re-engineering efforts in the company.
- **1984-19889: Senior Claims Adjuster – USF&G Insurance Company – Indianapolis, Indiana**
  - Responsible for handling general liability, auto and property claims, and special investigations.

Attachment 2

Summary Table –
Water Treatment Plant O&M Experience

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Attachment 2. Veolia - Water Treatment Plant O&M Experience Summary				
Client/Location	**Flow**	**Scope**	**Major Process(es)**	**Dates**
Ashburnham-Winchendon Joint Water Authority, MA	2 MGD	O&M of Surface Water Treatment Plant	Trident Filtration, Microfloc Microfiltration	2001-Ongoing
Blackwell, OK	1.55 MGD	O&M of Groundwater Treatment Plant	Conventional Treatment with Filtration	2001-Ongoing
Brockton, MA	24 MGD	O&M of Surface Water Treatment Plants	Conventional and GAC Filtration	1988-Ongoing
	1.3 MGD		Upflow Clarification, Direct Filtration, Microfloc Microfiltration	
Gloucester, MA	10 MGD	O&M of (two 5-MGD) Surface Water Treatment Plants	Conventional Treatment, Rapid Mix, Rapid Sand Filtration	2009-Ongoing
Heavener, OK	3 MGD	O&M of Surface Water Treatment Plant	Clarification, Filtration and Disinfection	1996-Ongoing
Latimer County, OK	0.23 MGD	O&M of Surface Water Treatment Plant	Surface Water Treatment Plant	2007-2017
Lynn, MA	15 MGD	O&M of Surface Water Treatment Plant	Rapid Mix Direct Filtration	1987-Ongoing
Leominster, MA	4 MGD	Design/Build and O&M for Multiple Surface Water Treatment Plants	Multi-Media Direct Filtration	1988-Ongoing
	2 MGD		GAC Filtration	
	1.2 MGD		Conventional (Rapid Mix, Upflow Pulsating Clarification, GAC Filtration)	
Sturbridge, MA	1.6 MGD	O&M of Groundwater Treatment Plant	Iron Removal Plant with Pressure, Greensand, Mixed-Media Filtration	1989-Ongoing
Westborough, MA	3.5 MGD	O&M of Surface and Groundwater Treatment Plants	Conventional Treatment, Multi-Media Filtration	1996-Ongoing
	2 MGD		Greensand Iron/ Manganese Removal	
City of Atlanta/ Fulton County, GA	90 MGD	O&M of Surface Water Treatment Plant	Conventional Treatment, Declining-Rate Filters	1991-Ongoing
Boonville, IN	2.9 MGD	O&M of Groundwater Treatment Plants	Iron/Manganese Oxidation, Dual-Media Greensand Pressure Filtration	1995-Ongoing
	1.9 MGD			
Buffalo, NY	160 MGD	O&M of Surface Water Treatment Plant	Conventional Treatment, Rapid Sand Filtration	2010-Ongoing
Canby Utility, OR	8 MGD	O&M of Surface Water Treatment Plant	Flocculation, Upflow Clarification, Filtration, UV Disinfection	2006-2016
Chattahoochee Valley Water Supply District, Lanett, AL	8 MGD	O&M of Surface Water Treatment Plant	Conventional Treatment, High-Rate, Multi-Media Filtration	1994-Ongoing

Attachment 2. Veolia - Water Treatment Plant O&M Experience Summary				
Client/Location	**Flow**	**Scope**	**Major Process(es)**	**Dates**
Discovery Bay, CA	8.21 MGD	O&M of Groundwater Treatment Plants	Iron Removal with Sand Filtration	2009-Ongoing
Edwardsville, IL	7.78 MGD	O&M of Groundwater Treatment Plants	Greensand Filtration and Zeolite Softening	1987-Ongoing
Hardinsburg, KY	2 MGD	O&M of Groundwater Treatment Plant and Surface Water Treatment Plant	Reverse Osmosis Filtration of Groundwater	1995-Ongoing
	1.2 MGD		Conventional Treatment, Surface Water Dual-Media Filtration with ClariCone Clarification	
Junction City, KS	10 MGD	O&M of Groundwater Treatment Plant	Aeration, Lime Softening	1989-Ongoing
Matewan, WV	0.05 MGD	O&M of Surface Water Treatment Plant	Conventional Filtration	2001-Ongoing
New London, CT	9 MGD	O&M of Surface Water Treatment Plant	Conventional Filtration	2008-Ongoing
National Park Service, Elwha River WTP, Port Angeles, WA	53 MGD	O&M of Surface Water Treatment Plant	Coagulation, Sedimentation	2009-Ongoing
Smugglers Notch, VT	0.15 MGD	O&M of Groundwater Treatment Plant	Pressure Vessel Filtration	1985-Ongoing
Springboro, OH	7 MGD	O&M of Groundwater Treatment Plant	Anthracite Multi-Media Filtration	1990-Ongoing
Tampa Bay Water, FL	120 MGD	DBO for Surface Water Treatment Plant (new plant and expansion)	ACTIFLO Flocculation, Ozonation, Carbon Filtration	2000-Ongoing
	30 MGD	O&M of Groundwater Treatment Plant	Hydrogen Sulfide Stripping via Aeration Towers and Scrubbers	
Tupelo, MS	12 MGD	O&M of Surface Water Treatment Plant	Infilco Filtration Systems	1991-Ongoing
Williamson, WV	4.2 MGD	O&M of Surface Water Treatment Plant	Direct Filtration & Conventional Filtration (GAC and Multi-Media)	1999-Ongoing
Wilsonville, OR	15 MGD	O&M of Surface Water Treatment Plant	ACTIFLO Flocculation, GAC Filtration Ozonation	2001-Ongoing
Yukon, OK	3 MGD	O&M of Groundwater Treatment Plant	Groundwater Treatment Plant	1991-Ongoing

Attachment 3

Affidavit for Corporate
Veolia Water North America Operating Services, LLC

VEOLIA

CITY OF FLINT, MICHIGAN

AFFIDAVIT

AFFIDAVIT FOR INDIVIDUAL

STATE OF ....
s.s.
COUNTY OF ....

....being duly sworn, deposes and says that he is the person making the above bid; and that said bid is genuine and not sham or collusive, and is not made in the interest of or on behalf of any person not therein named, and that he has not directly or indirectly induced or solicited any bidder to put in a sham bid; that he has not directly or indirectly induced or solicited any other person or corporation to refrain from bidding, and that he has not in any manner sought by collusion to secure to himself any advantage over other bidders.

Subscribed and sworn to before me at ...., in said County and State,

this .... day of .... , A. D. 20..........,

....

My Commission expires .... , 20.......... *Notary Public, ...County,............

FOR CORPORATION * (Limited Liability Company, LLC)

STATE OF Indiana
s.s.
COUNTY OF Marion

David M. Gadis being duly sworn, deposes and says

that he is Senior Vice President of Veolia Water North America Operating Services, LLC
(Official Title) (Name of Corporation) *

a corporation* duly organized and doing business under the laws of the State of Delaware (LLC) the corporation* making the within and foregoing bid; that he executed said bid in behalf of said corporation* by authority of its Board of Directors; that said bid is genuine and not sham or collusive and is not made in the interests of or on behalf of any person not herein named, and that he has not and said bidder has not directly or indirectly induced or solicited any bidder to put in a sham bid; that he has not and said bidder has not directly or indirectly induced or solicited any other person or corporation to refrain from bidding; that he has not and said bidder has not in any manner sought by collusion to secure to himself or to said corporation* an advantage over other bidders.

(Signature)

Subscribed and sworn to before me at Indianapolis, in said County and State,

this 27th day of January, A. D. 20 15,

Francis P. Crehan

*Notary Public, State of Indiana County, of Marion

My Commission expires July 24, 20 21.

FRANCIS P. CREHAN
Notary Public- Seal
State of Indiana
My Commission Expires Jul 24, 2021

EXHIBIT P

(Proposal #15-573)

EM SUBMISSION NO.: EMA 0372015

PRESENTED: 2-4-15

ADOPTED: 2-4-15

RESOLUTION TO VEOLIA WATER FOR WATER QUALITY CONSULTANT

BY THE EMERGENCY MANAGER

RESOLUTION

The Department of Purchases & Supplies has solicited a proposal to seek a water quality consultant as requested by the Utilities Department/Water Plant Division; and

Veolia Water, 101 West Washington St., Suite 1400 East, Indianapolis, IN was the sole bidder to submit from seven solicitations for said requirements. Funding for said services will come from the following accounts: 591-536.100-801.000; and

IT IS RESOLVED, that the Proper City Officials, upon the Emergency Manager's approval, are hereby authorized to enter into a contract with Veolia Water for water quality consulting in an amount not to exceed $40,000.00 (Water Fund)

APPROVED PURCHASING DEPT:

Derrick Jones, Purchasing Manager

APPROVED AS TO FINANCE:

Dawn Steele

Dawn Steele, Deputy Finance Director

APPROVED AS TO FORM:

Peter M. Bade, City Attorney

EM DISPOSITION:

ENACT X **REFER TO COUNCIL** ________ **FAIL** ________

Gerald Ambrose, Emergency Manager

DATED: 2/4/15

FY15 – DJ

DEPARTMENT OF PURCHASES AND SUPPLIES

Dayne Walling
Mayor

Derrick F. Jones
Purchasing Manager

February 6, 2015

TO: Brent Wright, Supervisor
Water Plant

FROM: Derrick F. Jones DFJ
Purchasing Manager

SUBJECT: VEOLIA WATER

Please be advised that the above mentioned vendor has been approved by the Emergency Manager on February 4, 2015. You may now enter a contract with Veolia Water for water quality consulting in an amount not to exceed $40,000.00.

If you have any questions, please call me.

DFJ/krn

Attachment

CITY OF FLINT CONTRACT WITH VEOLIA WATER NORTH AMERICA OPERATING SERVICES, LLC

The purpose of this agreement is to enter into a contract to provide consulting services related to the Flint Water Treatment System updates for the City of Flint (hereinafter "City") and Veolia Water North America Operating Services, LLC., (hereinafter "Contractor").

Applicable Law: This contract shall be governed by and interpreted according to the laws of the State of Michigan pertaining to contracts made and to be performed in this state.

Arbitration: Contractor agrees to submit to arbitration all claims, counterclaims, disputes, and other matters in question arising out of or relating to this agreement, Contractor must request consent to arbitrate within 30 days from the date the Contractor knows or should have known the facts giving rise to the claim, dispute or question.

(a) Notice of a request for arbitration must be submitted in writing by certified mail or personal service upon the City Attorney within a reasonable time after the claim; dispute or other matter in question has arisen. A reasonable time is hereby determined to be 14 days from the date the party demanding the arbitration knows or should have known the facts giving rise to his claim, dispute or question. In no event may the demand for arbitration be made after the time when institution of legal or equitable proceedings based on such claim dispute or other matters in question would be barred by the applicable statute of limitation.

(b) Within 60 days from the date a request for arbitration is received by the City, the City shall inform Contractor whether it agrees to arbitrate. If the City does not consent, Contractor may proceed with an action in the appropriate court. If the City does consent, then within 30 days of the consent each party shall submit to the other the name of one person to serve as an arbitrator. The two arbitrators together shall then select a third person, the three together shall then serve as a panel in all proceedings. Any unanimous decision of the three arbitrators shall be a final binding decision. The City's failure to respond to a timely, conforming request for arbitration is deemed consent to arbitration.

(c) The costs of the arbitration shall be spilt and borne equally between the parties and such costs are not subject to shifting by the arbitrator.

(d) Contractor's failure to comply with any portion (including timeliness) of this provision shall be deemed a permanent waiver and forfeiture of the claim, dispute, or question.

City Income Tax Withholding: Contractor and any subcontractor engaged in this contract shall withhold from each payment to his employees the City income tax on all of their compensation subject to tax, after giving effect to exemptions, as follows:

(a) Residents of the City:
At a rate equal to 1% of all compensation paid to the employee who is a resident of the City of Flint.

(b) Non-residents:
At a rate equal to 1/2% of the compensation paid to the employee for work done or services performed in the City of Flint.

These taxes shall be held in trust and paid over to the City of Flint in accordance with City ordinances and State law. Any failure to do so shall constitute a substantial and material breach of this contract.

Compensation: The City shall pay for requested services plus expenses as have been set forth herein, a contract price not to exceed $ 40,000.00 upon submission of proper invoices, releases, affidavits, and the like. Contractor recognizes that the City does not guarantee it will require any set amount of services. Contractor's services will be utilized as needed and as determined solely by the City of Flint. Contractor expressly recognizes that it has no right to payment of any amount exceeding $40,000.00 Contractor agrees that oral agreements by City officials to pay a greater amount are not binding.

1. Contractor shall submit itemized invoices for all services provided under this Agreement identifying:

(a) The date of service
(b) The name of person providing the service and a general description of the service provided.
(c) The unit rate and the total amount due.

Invoices shall be submitted to:

City of Flint
Accounts Payable
P.O. Box 246
Flint, MI 48501-0246

City of Flint
Utilities Department
4500 North Dort Highway
Flint, Michigan 48505

Or email to:**accountspayable@cityofflint.com**

The City may require additional information or waive requirements as it sees fit. The City will notify the Contractor of any errors or lack of sufficient documentation within 14 days of receipt of the invoice.

Contract Documents: The invitation for bids, instructions to bidders, proposal, affidavit, addenda (if any), statement of bidder's qualifications (when required), general conditions, special conditions, performance bond, labor and material payment bond, insurance certificates, technical specifications, and drawings, together with this agreement, form the contract, and they are as fully a part of the contract as if attached hereto or repeated herein.

Disclaimer of Contractual Relationship With Subcontractors: Nothing contained in the Contract Documents shall create any contractual relationship between the City and any Subcontractor or Sub-subcontractor.

Effective Date: This contract shall be effective upon the date that it is executed by all parties and presented to the City of Flint Clerk.

Certification, Licensing, Debarment, Suspension and Other Responsibilities: Contractor warrants and certifies that Contractor and/or any of its principals are properly certified and licensed to perform the duties required by this contract in accord with laws, rules, and regulations, and it not presently debarred, suspended, proposed for debarment or declared ineligible for the award of Federal contracts by any Federal agency. Contractor may not continue to or be compensated for any work performed during any time period where the debarment, suspension or ineligibility described above exists or may arise in the course of Contractor contractual relationship with the City. Failure to comply with this section constitutes a material breach of this Contract. Should it be determined that contractor performed work under this contract while non-compliance with this provision, Contractor agrees to reimburse the City for any costs that the City must repay to any and all entities.

Force Majeure: Neither party shall be responsible for damages or delays caused by Force Majeure or other events beyond the control of the other party and which could not reasonably have been anticipated or prevented. For purposes of this Agreement, Force Majeure includes, but is not limited to, adverse weather conditions, floods, epidemics, war, riot, strikes, lockouts, and other industrial disturbances; unknown site conditions, accidents, sabotage, fire, and acts of God. Should Force Majeure occur, the parties shall mutually agree on the terms and conditions upon which the services may continue.

Good Standing: Contractor must remain current and not be in default of any obligations due the City of Flint, including the payment of taxes, fines, penalties, licenses, or other monies due the City of Flint. Violations of this clause shall constitute a substantial and material breach of this contract. Such breach shall constitute good cause for the termination of this contract should the City of Flint decide to terminate on such basis.

Hold Harmless and Indemnification: To the fullest extent permitted by law, thei City and Contractor (hereinafter in this section the "Indemnifying Party") each agree to defend, pay on behalf of, indemnify, and hold harmless the other Party ("Indemnified Party"),its elected and appointed officials, employees, volunteers and others working on behalf of the Indemnified Party, against any and all claims, demands, suits, or losses, including all costs connected therewith, and for any and all damages which may be asserted, claimed, or recovered against or from the Indemnified Party, its elected and appointed officials, employees, volunteers or others working on behalf of the City, arising out of this Agreement, including but not limited to those by reason of personal injury, including bodily injury or death and/or property damage, including loss of use thereof, including those which may arise as a result of the Indemnifying Party's acts, omissions, faults, and negligence or that of any of his employees, agents, and representatives.

Independent Contractor: No provision of this contract shall be construed as creating an employer-employee relationship. It is hereby expressly understood and agreed that Contractor is an "independent contractor" as that phrase has been defined and interpreted by the courts of the State of Michigan and, as such, Contractor is not entitled to any benefits not otherwise specified herein.

Insurance/Worker's Compensation: Contractor shall not commence work under this contract until he has procured and provided evidence of the insurance required under this section. All coverage shall be obtained from insurance companies licensed and authorized to do business in the State of Michigan unless otherwise approved by the City's Risk Manager. All coverage shall be with insurance carriers reasonably acceptable to the City of Flint. Contractor shall maintain the following insurance coverage for the duration of the contract.

(a) Commercial General Liability coverage of not less than one million dollars ($1,000,000) combined single limit with the City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers, named as "Additional Insureds" with respect to Contractor's duties and activities under the scope of this Agreement. This coverage shall include the following coverages as found in the most current edition of the ISO occurrence basis form CG 00 01: Bodily Injury, Personal Injury, Property Damage, Contractual Liability, Products and Completed Operations, Independent Contractors; Broad Form Commercial General Liability Endorsement and (XCU) Exclusions deleted. This coverage shall be primary to the Additional Insureds, and not contributing with any other insurance or similar protection available to the Additional Insureds, whether said other available coverage be primary, contributing, or excess.

(b) Workers Compensation Insurance in accordance with Michigan statutory requirements, including Employers Liability coverage with limits of one million dollars ($1,000,000) per accident.

(c) Commercial Automobile Insurance in the amount of not less than $1,000,000 combined single limit per accident with the City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers, named as "Additional Insureds." This coverage shall be written on ISO business auto forms (or its equivalent) covering Automobile Liability, code "any auto."

(d) Professional Liability - Errors and Omissions. All projects involving the use of Architects, civil engineers, landscape design specialists, and other professional services must provide the City of Flint with evidence of Professional Liability coverage in an amount not less than one million dollars ($1,000,000). Evidence of this coverage must be provided for a minimum of three years after project completion.

Contractor shall furnish the City with a certificate of insurance for all coverage requested with original endorsements as required herein for those policies requiring the Additional Insureds. The certificate must identify the City of Flint, Risk Management Division, as the "Certificate Holder." If any of the above polices are due to expire during the term of this contract, Contractor shall deliver renewal certificates to the City of Flint with in ten business days of the expiration date. Contractor shall ensure that all subcontractors utilized obtain and maintain all insurance coverage required by this provision.

Laws and Ordinances: Contractor shall obey and abide by all of the laws, rules and regulations of the Federal Government, State of Michigan, Genesee County and the City of Flint, applicable to the performance of this agreement, including, but not limited to, labor laws, and laws regulating or applying to public improvements.

Modifications: Any modifications to this contract must be in writing and signed by the parties or the authorized employee, officer, board or council representative of the parties authorized to make such contractual modifications under State law and local ordinances.

No Third-Party Beneficiary: No contractor, subcontractor, mechanic, materialman, laborer, vendor, or other person dealing with the principal Contractor shall be, nor shall any of them be deemed to be, third-party beneficiaries of this contract, but each such person shall be deemed to have agreed (a) that they shall look to the principal Contractor as their sole source of recovery if not paid, and (b) except as otherwise agreed to by the principal Contractor and any such person in writing, they may not enter any claim or bring any such action against the City under any circumstances. Except as provided by law, or as otherwise agreed to in writing between the City and such person, each such person shall be deemed to have waived in writing all rights to seek redress from the City under any circumstances whatsoever.

Non-Assignability: Contractor shall not assign or transfer any interest in this contract without the prior written consent of the City provided, however, that claims for money due or to become due to Contractor from the City under this contract may be assigned to a bank, trust company, or other financial institution without such approval. Notice of any such assignment or transfer shall be furnished promptly to the City.

Non-Disclosure/Confidentiality: Contractor agrees that the documents identified herein as the contract documents are confidential information intended for the sole use of the City and that Contractor will not disclose any such information, or in any other way make such documents public, without the express written approval of the City or the order of the court of appropriate jurisdiction or as required by the laws of the State of Michigan.

Non-Discrimination: Contractor shall not discriminate against any employee or applicant for employment with respect to hiring or tenure; terms, conditions, or privileges of employment; or any matter directly or indirectly related to employment, because of race, color, creed, religion, ancestry, national origin, age, sex, height, weight, disability or other physical impairment, marital status, or status with respect to public assistance.

Notices: Notices to the City of Flint shall be deemed sufficient if in writing and mailed, postage prepaid, addressed to **Howard Croft, Department of Public Works Director, 1101 South Saginaw, Flint, Michigan 48502** and **Inez Brown, City Clerk, City of Flint, 1101 S. Saginaw Street, Flint, Michigan 48502**, or to such other address as may be designated in writing by the City from time to time. Notices to Contractor shall be deemed sufficient if in writing and mailed, postage prepaid, addressed to **General Counsel, 200 E. Randolph St., Suite 7900, Chicago, IL 60601** , or to such other address as may be designated in writing by Contractor from time to time.

Payments to Contractor by Client shall be by check payable to Contractor addressed to Contractor's address or by electronic transfer.

R-12 Prevailing Wages: Contractor is aware of City of Flint Resolution #R-12 dated April 8, 1991, which is hereby incorporated by reference, and agrees to abide by all of the applicable covenants and requirements set forth in said resolution.

Records Property of City: The contractor will provide a copy of all documents, information, reports and the like prepared or generated as a result of this contract to the City of Flint.

Scope of Services: Contractor shall provide all of the materials, labor, equipment, supplies, machinery, tools, superintendence, insurance and other accessories and services necessary to complete the project in accordance with the proposals submitted on January 29, 2015 . Contractor shall perform the work in accordance with the Standard General Conditions and the Additional Terms and Conditions provided for in this contract in Exhibit A hereto.

Severability: In the event that any provision contained herein shall be determined by a court or administrative tribunal to be contrary to a provision of state or federal law or to be unenforceable for any reason, then, to the extent necessary and possible to render the remainder of this Agreement enforceable, such provision may be modified or severed by such court or administrative tribunal so as to, as nearly as possible, carry out the intention of the parties hereto, considering the purpose of the entire Agreement in relation to such provision. The invalidation of one or more terms of this contract shall not affect the validity of the remaining terms.

Standards of Performance: Contractor agrees to exercise independent judgment and to perform its duties under this contract in accordance with sound professional practices. The City is relying upon the professional reputation, experience, certification, and ability of Contractor. Contractor agrees that all of the obligations required by him under this Contract shall be performed by him or by others employed by him and working under his direction and control. The continued effectiveness of this contract during its term or any renewal term shall be contingent upon Contractor maintaining any required certification in accordance with the requirements of State law.

Subcontracting: No subcontract work, if permitted by the City, shall be started prior to the written approval of the subcontractor by the City. The City reserves the right to accept or reject any subcontractor.

Termination: This contract may be terminated by either party hereto by submitting a notice of termination to the other party, pursuant to Article III of Exhibit A herein. Such notice shall be in writing and shall be effective 10 days from the date it is submitted unless otherwise agreed to by the parties hereto. Contractor, upon receiving such notice and prorated payment upon termination of this contract shall give to the City all pertinent records, data, and information created up to the date of termination to which the City, under the terms of this contract, is entitled.

Time of Performance: Contractor's services shall commence immediately upon receipt of the notice to proceed and shall be carried out forthwith and without reasonable delay.

Union Compliance: Contractor agrees to comply with all regulations and requirements of any national or local union(s) that may have jurisdiction over any of the materials, facilities, services, or personnel to be furnished by the City.

Waiver: Failure of the City to insist upon strict compliance with any of the terms, covenants, or conditions of this Agreement shall not be deemed a waiver of any term, covenant, or condition. Any waiver or relinquishment of any right or power hereunder at any one or more times shall not be deemed a waiver or relinquishment of that right or power at any other time.

Whole Agreement: This written agreement and the documents cited herein embody the entire agreement between the parties. Any additions, deletions or modifications hereto must be in writing and signed by both parties.

IN WITNESS WHEREOF, the parties have executed this contract this (day) 10th of DLC February, 2015.

CONTRACTOR:

Its ____________________

WITNESS(ES):

CITY OF FLINT, a Michigan Municipal Corp.:

Gerald Ambrose
Emergency Manager

APPROVED AS TO FORM:

For

Peter M. Bade
Chief Legal Officer

EXHIBIT A
Additional Terms and Conditions

ARTICLE I – DEFINITION OF WORK

Contractor shall, as an independent contractor and not as an employee or agent of theCity, provide consulting and related services to Client in connection with the Project as outlined in Contractor's Proposal dated January 29, 2015, attached hereto as Exhibit A, hereinafter referred to as the "Services".

ARTICLE II - PAYMENTS

For Services enumerated under this Agreement, the City agrees to pay and Contractor agrees to accept compensation and the payment terms outlined as follows:

Contractor shall be paid a firm fixed fee of $225 per person per hour to perform the Services, as defined further in Article VII. As further defined in this section, the Services provided shall not exceed the following: for the One Week Assessment the fee paid by the City shall not exceed $40,000 for labor and expenses. Contractor shall submit an invoice as soon as practicable after the Project is completed. Invoices so submitted shall be paid within thirty (30) days after receipt byCity.

ARTICLE III - TERM

The Agreement shall be effective as of the date of this Agreement and shall continue for a term not to exceed sixty days.

ARTICLE IV – LIMITATION OF LIABILITY

IN NO EVENT SHALL CONTRACTOR BE LIABLE TO CLIENT FOR INCIDENTAL, INDIRECT, CONSEQUENTIAL, SPECIAL, PUNITIVE OR EXEMPLARY DAMAGES OF ANY KIND - INCLUDING LOST REVENUES OR PROFITS, LOSS OF BUSINESS OR LOSS OF DATA - ARISING OUT OF THIS AGREEMENT (INCLUDING WITHOUT LIMITATION AS A RESULT OF ANY BREACH OF ANY TERM OF THIS AGREEMENT), REGARDLESS OF WHETHER CONTRACTOR WAS ADVISED, HAD OTHER REASON TO KNOW, OR IN FACT KNEW OF THE POSSIBILITY THEREOF.

CONTRACTOR'S LIMIT OF LIABILITY UNDER THIS AGREEMENT SHALL IN NO EVENT EXCEED THE TOTAL PAYMENTS MADE BY CLIENT TO CONTRACTOR.

ARTICLE V – SCOPE OF WORK

The City has asked that work be carried out in stages. This is reflected in the January 29, 2015 Veolia proposal (the Proposal) both in text and in graphics. The initial stages to be carried out are more specifically defined below. The findings in those stages will be used to further identify future work. The Services to be provided are:

One Week Assessment - This involves a Kick Off meeting with the client and a Top Down assessment as defined in the Proposal. Veolia would provide two water and two communication experts for a total of 40 hours each at $225 an hour plus expenses. The product from that week would be a letter or power point presentation reviewing actions taken by the City to date, validating what has been done by the city to date and plans proposed going forward making recommendations for other ideas to try, putting a schedule together for those ideas s if more study or other actions is needed to investigate ideas.. The scope of work will involve the water plant, distribution system and communications with customers. This would include a presentation of the findings to stakeholders and others upon the city's request. The City would provide access to staff, consultants and records for review.

Implementation and Management Assistance - The RFP asked for additional services over a longer period of time. At this point it is not clear if additional services are needed, what type of service this would involve, how the services would be provided and for how long. Any such additional services, terms and

conditions therefore would be negotiated at a later date, whether through change order, amendment or otherwise.

ACORD®

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY) 02/09/2015

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Marsh USA, Inc.
540 W. Madison Street
Chicago, IL 60661
Attn: Veolia.CertRequest@marsh.com | Fax: 212-948-5053

CONTACT NAME:
PHONE (A/C, No, Ext): FAX (A/C, No):
E-MAIL ADDRESS:

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A: ACE American Insurance Company	22667
INSURER B: ACE Fire Underwriters Insurance Company	20702
INSURER C: Illinois Union Insurance Company	27960
INSURER D: N/A	N/A
INSURER E:	
INSURER F:	

INSURED
Veolia Water North America Operating Services, LLC
101 West Washington Street, Suite 1400
Indianapolis, IN 46204

COVERAGES CERTIFICATE NUMBER: CHI-005103069-01 REVISION NUMBER: 2

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	GENERAL LIABILITY X COMMERCIAL GENERAL LIABILITY CLAIMS-MADE X OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: X POLICY PRO-JECT LOC			HDO G27340167	01/01/2015	01/01/2016	EACH OCCURRENCE	$ 1,000,000
							DAMAGE TO RENTED PREMISES (Ea occurrence)	$ 1,000,000
							MED EXP (Any one person)	$ 10,000
							PERSONAL & ADV INJURY	$ 1,000,000
							GENERAL AGGREGATE	$ 1,000,000
							PRODUCTS - COMP/OP AGG	$ 1,000,000
								$
A	AUTOMOBILE LIABILITY X ANY AUTO ALL OWNED AUTOS SCHEDULED AUTOS HIRED AUTOS NON-OWNED AUTOS			ISA H0883040A	01/01/2015	01/01/2016	COMBINED SINGLE LIMIT (Ea accident)	$ 1,000,000
							BODILY INJURY (Per person)	$
							BODILY INJURY (Per accident)	$
							PROPERTY DAMAGE (Per accident)	$
								$
	UMBRELLA LIAB OCCUR EXCESS LIAB CLAIMS-MADE DED RETENTION $						EACH OCCURRENCE	$
							AGGREGATE	$
								$
A B	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY Y/N ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? N (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below	N/A		WLR C48139814 (AOS) SCF C48139838 (WI)	01/01/2015 01/01/2015	01/01/2016 01/01/2016	X WC STATU-TORY LIMITS OTH-ER	
							E.L. EACH ACCIDENT	$ 1,000,000
							E.L. DISEASE - EA EMPLOYEE	$ 1,000,000
							E.L. DISEASE - POLICY LIMIT	$ 1,000,000
C	Contractors' Pollution and Professional Liability			GOO G27269096 001 CPL SIR = $250,000	07/01/2013	01/01/2016	Each Occurrence Prof Liab SIR = $1,000,000	1,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (Attach ACORD 101, Additional Remarks Schedule, if more space is required)

City of Flint, and including all elected and appointed officials, all employees and volunteers, all boards, commissions and/or authorities and their board members, employees and volunteers are included as additional insured (except workers' compensation and professional liability) where required by written contract. This insurance is primary and non-contributory over any existing insurance and limited to liability arising out of the operations of the named insured and where required by written contract.

CERTIFICATE HOLDER

City of Flint
Risk Management Division
4500 North Dort Highway
Flint, MI 48505

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE
of Marsh USA Inc.
Manashi Mukherjee Manashi Mukherjee

EXHIBIT Q

From: Chen, Depin (Theping) [theping.chen@veolia.com]
Sent: Monday, February 02, 2015 12:23 AM
To: David Gadis
CC: Nicholas, Robert; Low, Manshi; Cathy Dennis; Jonathan Carpenter; Marvin Gnagy
Subject: Re: Flint, Michgan

I just want to share with you some of the information I found out after today's conference call.

I should correct my original guesses of why no other consultants have responded to the RFP. The consultant may be expected to play a difficult role.

First, the residents are unhappy with many aspects of the water quality, mainly judging from the aesthetic quality (color, taste, solids, and smell) and some perceived health issues (skin rashes, even dog death, etc.) The City and the Mayor are insisting the water is safe, the MDEQ won't issue a blank statement as it only regulates specific water quality parameters such as TTHMs but not aesthetic water quality. The City and MDEQ agree that TTHMs only affects a small population.

Some citizens, now with the support from Erin Brockovich, are organizing protests and even threaten lawsuits against the City (some even suggest past consultants).

Link to Erin Brockovich news:
http://patch.com/michigan/fenton/erin-brockovich-keeping-eye-flints-poop-water-0

City of Flint has long been suffering financial problems, and has disputes with the DWSD regarding its water rates. The decision to terminate contract with DWSD and join the Karegnondi Water Authority is a way to gain control and achieve savings from the $12M annual cost for buying DWSD water. One consultant's estimates are $50M to upgrade the plant to treat Flint River water and $10M to upgrade the plant to treat Lake Huron Water (when the pipeline is ready in summer 2016). The City has spent $7M on plant upgrade so far (not sure for pipeline or process, there is $0.75M for a new roof).

According to the news and the following link of NBC News, DWSD has just offered to reconnect the DWSD supply line to Flint with no strings attached (no re-connection fee, no long term contract). Many residents are asking to have the DWSD water back (until the new pipeline is ready), including some of the council members. City Emergency Manager and Mayor have insisted the approach of using an outside consultant to solve the problem in 30-60 days.

Link to Local NBC News.
https://www.youtube.com/watch?v=MYXrC_aqkRk

My assessment is that the City's expectation on the consultant is unrealistic. There is no small tweaking will allow the City to comply with the TTHMs regulation, or implement any engineering solutions to reduce TTHMs within 30-60 days. Yet, TTHMs is not even in most of residents mind. Their concerns are of overall water quality issues comparing to DWSD water.

The cheapest and highly effective alternative may be to switch to chloramine as secondary disinfectant. Others quick and cheap solutions may include aeration in the clearwell or storage tanks. These will cost a few million dollars and take several months at least to construct and implement, and more time to optimize. There may still some changes coould upset the residents. Especially Erin Brockovich is against chloramine, and there will be activists and residents who distrust City will launch public campaign against it. The amount of time and effort spent may not be worth it or delay the implementation too much to be of any real value. The City will have no use of the chloramine system when the Lake Huron Water is online.

Chloramine alone may not work. Any additional TOC reduction measures including MIEX, GAC

contactor (as used in Celina Ohio on similar TOC water) and UV system (for primary disinfectant) may cost up to $10M each. Even the upgrades (will need 6 months or longer to implement) will address the TTHMs issues, the residents may still find the faults with it when comparing to DWSD water, and blame any unrelated issues (such as plumbing problems caused red water) to the Flint River water.

It seems that reconnecting to the DWSD for the next two years will be the best solution to satisfy the residents and activists. The Emergency Manager and Mayor may not like it for political (mostly) and financial reasons, they should not have unrealistic and false hopes either.

Best regards,
Theping

On 1 February 2015 at 13:58, David Gadis <david.gadis@me.com> wrote:

> Thanks
>
> Sent from my iPhone
>
> On Feb 1, 2015, at 1:39 PM, "Depin (Theping) Chen" <theping.chen@veolia.com> wrote:
>
> > Just saw the e-mail string. I will call in.
> >
> > On Feb 1, 2015, at 1:18 PM, Nicholas, Robert <robert.nicholas@veolia.com> wrote:
> >
> > > I will be on it
> > >
> > > On Sunday, February 1, 2015, David Gadis <david.gadis@me.com> wrote:
> > >
> > > > We will have a call a call at 2:00pm est. call in info is as follows: 866-506-1253
> > > > Pass code: 765-592-1146. I hope you can each join. Thanks
> > > >
> > > > Sent from my iPhone
> > > >
> > > > On Feb 1, 2015, at 12:04 PM, David Gadis <david.gadis@me.com> wrote:
> > > >
> > > > > Thanks Manshi.
> > > > >
> > > > > Sent from my iPhone
> > > > >
> > > > > On Feb 1, 2015, at 11:47 AM, "Low, Manshi" <manshi.low@veolia.com> wrote:
> > > > >
> > > > > > I'm available all day today except 3-5 pm EST.
> > > > > >
> > > > > > On Feb 1, 2015 8:29 AM, "David Gadis" <david.gadis@me.com> wrote:

Ok, you are correct, I am in the air at that time. I want to talk about how we handle questions, such as, if asked for an overview of our proposal and how long will this take? Who and how do we answer? I will set a call for today once I hear from others. Thanks

Sent from my iPhone

On Feb 1, 2015, at 11:22 AM, "Nicholas, Robert" <robert.nicholas@veolia.com> wrote:

> Good morning
>
> I am available today.
>
> Have a call set up for tomorrow at 10 am with Marvin and the Theping. I think you said you would be in the air.
>
> We haven't heard back from Marvin on that and he shows being out all day so don't know that he is available for either call.
>
> On Sunday, February 1, 2015, David Gadis <david.gadis@me.com> wrote:
>
>> Team, I hate to bother you on a Sunday especially Super Bowl Sunday. But I think we need to talk before our call with Flint tomorrow. Can we talk today before you all start your game time fun? Thanks
>>
>> Sent from my iPhone
>
> --
> Rob Nicholas
> *Vice President, Development*
> *Municipal & Commercial Business*
> *VEOLIA NORTH AMERICA*
>
> tel +1 859 582 0104
> 5071 Endview Pass /
> Brooksville, FL 34601
> Robert.Nicholas@veolia.com
> www.veolianorthamerica.com

Resourcing the world VEOLIA

--

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Resourcing the world VEOLIA

--

Theping Chen
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Municipal & Commercial Business
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7340 Hillside Lane / Solon, OH 44139
theping.chen@veolia.com
www.veolianorthamerica.com

Resourcing the world VEOLIA

EXHIBIT R

MEMO TO: Scott Edwards, Senior Vice President, Communications
Veolia North America

FROM: Kelly Rossman-McKinney, CEO

IN RE: Flint Launch Recommendations

As we discussed Monday, Flint's water situation has nowhere to go but up. I'm sending you background on the situation in a separate document but it is true that the city has been teeing up Veolia's arrival. The city manager has said to me "I'm not sure it's the cavalry coming in. It is bringing in an extra set of eyes to make sure we are doing everything we need to do to assure safe water and improved quality.

Based on that, I recommend we announce Veolia's contract with the city as follows:

1. Hold a brief introductory meeting for the city and Veolia to meet with a few key individuals in advance of any formal announcement. A handful participated in a news conference announcing the state's commitment and the city's emergency manager strongly recommends something similar. This will help ensure we have some folks who are willing to reinforce the importance of Veolia's role in helping address Flint's current water situation. (We will coordinate with Harvey Hollins, the Governor's point person for urban communities, to help put this together.)
2. Hold a media roundtable Monday afternoon, February 9. Participants would include the emergency manager (Jerry Ambrose), the mayor (Dayne Walling), and the public works director (Howard Croft) along with Veolia's reps (David Gadis and Rob *****). Purpose will be to announce Veolia's arrival and outline the work they will be doing for Flint (assessment, recommendations, next steps followed by more in-depth study). I recommend a roundtable because the format allows for a much more back-and-forth conversation/discussion than a news conference does.
    a. An advisory will be prepared and distributed Monday morning to reporters.
    b. A news release will be prepared and distributed at the event and then post-event to any reporters not attending.
    c. Talking points and FAQs will need to be prepared for all participants in advance to ensure consistency and continuity. We need to make sure to emphasize from our city reps that Veolia was the only expert to respond to the RFP.
3. Veolia will be introduced by the emergency manager to the City Council that evening at its regularly scheduled meeting.

Although I'm not sure we mentioned this in our call Monday, Flint is an urban community with a very strong African-American presence and we must be mindful of this as we move forward. As we have discussed regarding Detroit, having a person of color as Veolia's cpokesperson will be helpful.

Also, we need to do a couple of pre-emptive strikes to ensure we've kept key folks informed, including:

- Brad Wurfel, Public Information Officer, Michigan Department of Environmental Quality Brad has a good relationship with Fonger and can be helpful. I also want to make sure Brad says good, positive things about Veolia.
- Sara Wurfel, Governor Rick Snyder's press secretary. (Yes, she is married to Brad.)
- Rich Baird, right hand to the Governor (not even sure what his title as!) and key to appointing the emergency manager.
- Flint legislators, including Congressman Dan Kildee (his campaign treasurer is our COO), State Senator Jim Ananich, and other local legislators.

The city of Flint has one communications point person, Jason Lorenz, who we have worked with on several fronts on a pro bono basis. He is a one-man shop and coordinates a number of issues simultaneously, so he will be grateful for the help on our end.

I look forward to our call tomorrow morning and will be sending our summary and background information in a separate document.

EXHIBIT S

VEOLIA

Flint: Key Messages - DRAFT

February 5, 2015

Key messages for Flint announcement

- The city retained Veolia to conduct a scientific analysis of the water system. We anticipate that the analysis will last less than two weeks and we will then present our findings to the city.
- Until Veolia conducts an analysis, we cannot say for certain how long it will take to fix the system. We will present our findings in our analysis.
  - Veolia's analysis will review lab tests, the plant and pipes, operating practices, chemicals, lab testing procedures as well as the way the facility communicates with its customers. The objective is to determine potential solutions but to make sure that changes are carefully thought out and analyzed for safety before moving forward.
- Veolia offered to help Flint with its challenges because our work in other cities makes us uniquely positioned to do so. We have extensive experience in handling difficult river water sources, reducing leaks and contaminants and in managing discolored water.
- Veolia is the world's largest water services company, managing more than 8,000 water and wastewater treatment facilities around the world – 24/7. No other company or city manages these levels of water treatment each day.
- In addition to experts trained in scientific analysis, Veolia staff consists of engineers and operators that are skilled in running this type of water facility. We would be happy to help the people of Flint, including its most vulnerable, solve their water issues and return to clear, healthy water. A decision on how to move forward with the analysis will be made by the city.
- We understand the frustration and the urgency felt by the community of Flint, as the need for clean water unites us all. We're very excited to support the community with our technical expertise so that together, we can ensure quality water for everyone.

Key Case Studies

- **Tampa Bay**: Flint recently started drawing surface water from the river, which is highly variable in terms of water quality. When we started work in Tampa Bay, the region faced the same problem. They needed a new water supply source but the proposed site was adjacent to wetlands and other natural systems, making it subject to variable conditions in flows and raw water quality. Veolia brought together a team with special skills in operations and water treatment technologies. The result is that Tampa Bay Water's water quality now meets or exceeds the requirements of the Florida EPA. A detailed monitoring plan was developed and

implemented to ensure consistent evaluation of the withdrawals from the water supply sources to prevent environmental harm.

- Case study: http://goo.gl/Swpu2U
- Smart Planet: http://goo.gl/e8hTny
- CNN Money: http://goo.gl/1bU76u

- **Wilsonville, Ore.** – Much like Flint, the city of Wilsonville, Ore. (a Portland suburb) draws from highly variable river water. Veolia helped the city start its new plant, which has surpassed the client's goals and objectives for producing outstanding water quality.
  - Case Study: http://goo.gl/FjgipQ
  - Treatment Plant Operator: http://goo.gl/IDBsFh

- **Brockton, Ont.** – In May 2000, seven people died and approximately 2,500 residents fell ill after the drinking supply in Walkerton, Ont. (now Brockton, Ont.) was contaminated with E.coli bacteria. This terrible tragedy further damaged trust between the residents and government. After initially using the services of the Ontario Clean Water Agency (OCWA), the municipality retained Veolia to operate its water and wastewater systems. Veolia assessed health and safety issues, and improved the safety of the water supply systems using online analytical equipment. Brockton residents now trust the safety and quality of their water, and in 2010, Brockton commemorated the ten-year anniversary of the tragedy by encouraging youth to become leaders in North American water management.
  - Case Study: http://goo.gl/ESFfyP
  - From Water Tragedy to Water Excellence: http://goo.gl/2FodBl

ROUGH FAQ DRAFT FOR PAUL TO CANNIBALIZE

Why are you here?

- The city hired Veolia to conduct a scientific analysis of Flint's water. Our analysis will last approximately x weeks, and then we'll present the findings of our scientists to the city.

Will you fix the city's water?

- We are being retained to conduct a scientific analysis of Flint's water.
- We haven't yet looked at the system, so we don't yet know how the system would be fixed or how long it would take. Those findings will be in our scientific analysis.

Are you going to present the problem and fix it?

- In addition to scientific expertise, Veolia's staff consists of engineers and operators. We would be happy to help the people of Flint, including its most vulnerable, solve their water issues and get back to clear, healthy water.
- That decision is ultimately the city's.

Isn't Veolia bad for the environment?

- Veolia is great for the environment. We are the world's largest water services company, managing more than 8,500 water and wastewater facilities around the world – 24/7. No other company or city manages these levels of water treatment each day.

- We chose to help Flint because our work in other cities makes us uniquely positioned to do so: [case studies]

This bid was rushed.
There were x public hearings and it occurred over x amount of time and was well within typical procurement rules. But how long do you want to wait to bring in scientists to analyze your water? If you want more politics, go ahead.

Details on the bid

We could do it ourselves.
That's a question for the city, although the reason they've asked for help is clear based on media reports. Our job is to help analyze the water for Flint, to help people regardless of income level, have healthy drinking water.

You can ask the city why they asked for help, but our job is to support them in helping all people, regardless of race or income level, have healthy drinking water. We're here to support those groups.

Details on the problem

- According to a story in MLive, Mayor Dyne Walling has estimated that the Flint water plant and distribution systems need "$50 million in upgrades in the next six years alone." http://goo.gl/u9mgQP
- Tests in May, August and November showed that the city is in violation of the Safe Drinking Water Act. The tests showed a "high level of total trihalomethanes in the water," according to Mlive. And according to that same article, "residents have flooed City Hall with complaints about the smell, taste and color of water" since April. http://goo.gl/u9mgQP
- Further, State Rep. Sheldon Neeley said "in a letter to the governor that his constituents 'are on the verge of civil unrest' because of issues with water in the city, which charges customer more than any other public water system in Genesee

Why were you the only bidder?
We're not sure, as we were eager to help the people of Flint. The city actually extended its due date for proposals, but ultimately only Veolia submitted to analyze the water. Perhaps other companies shied away from the challenge.

How much will cost?

Contract value?

Have you done this before?

What is your role?

What are your next steps?

When will you give the city a report and recommendations?

What are you doing in Detroit?

Will you own the system?

Is this a Trojan horse?

When are you guys going to fix this?

NOTES
Indy – 8 sources of water, Eagle Creek – fixed taste and odor issues, knocked down complaints to a dozen

Where have you done this?

- When we started up the plant in Tampa Bay, we did all three.
- Changes in the water are not unusual. We have started up new plants with variable water quality.
- Tampa Bay – three water sources.
- Indy – lots of stuff
- Any times you start up a plant.
- We've encountered trihalomethanes before…a new plant to a well – you make operating changes
- Bill Fahey is probably better to ask – or ask Marvin directly
- Ask about changing water sources, trihalomethanes and chlorine residuals in the distribution system and then discoloration of the water – the problem here is that all of these problems are happening at one time
- Periodically you get turbid water in the line – it happens in water systems for a wide range of regions
- River sources are more difficult (surface water) and they just might not be familiar with it
- Look, we haven't even seen the plant
- First week we're just going to analyze the water, give the ideas that

EXHIBIT T

Michigan

University of Michigan-Flint reveals water quality test results to campus

By **Sarah Schuch | sschuch@mlive.com**
on February 09, 2015 at 5:02 PM

FLINT, MI -- Test results for water on the University of Michigan-Flint campus revealed that water is safe to drink throughout campus except for two isolated locations.

The full results of UM-Flint's water testing were shared with the campus community on Friday, Feb. 6, and showed that two areas on campus showed high levels of lead and that some water should not be used for drinking.

Mike Lane, director of Environment, Health, and Safety at UM-Flint, said even though further testing is being done on those sections of campus, the issues are not related to the city of Flint's overall struggles with transitioning to using the Flint River as its primary water source.

UM-Flint and Mott Community College made the decision to do their own water quality testing on their respective campuses after the city of Flint notified customers in January that the city is in violation of the federal Safe Water Drinking Act due to high levels of

FLINT RIVER WATER

a disinfectant byproduct called total trihalomethane, or TTHM, in the water system in 2014.

UM-Flint's results, provided by an independent consultant, showed low levels of TTHM.

"However, in the first round of sampling there were two isolated fountains within two separate buildings where the test data initially showed poor water quality," the email read. "(Environment, Health and Safety) shut down those fountains, retested and continues to investigate."

The two fountain locations were the third floor Northbank Center South building hallway and the Central Energy Plant on the first floor.

Occupants in the Northbank Center South building are asked not drink the water until further notice due to elevated lead concentration.

Drinking fountains and sinks will be marked with signs until it's safe to drink the water, Lane said.

The issues could stem from old pipes or other pipe or water system issues, Lane said. Investigation is still ongoing to correct the issue in the Northbank Center South building, which houses research offices, attorney offices and other office space for organizations.

There is no classroom space in the affected building, Lane said.

'Beginning of the end' for Flint water crisis health disaster, Edwards says

Watch live as new Flint water test results are announced by Virginia Tech

Water resources sites up and running in all nine Flint wards

W.K. Kellogg Foundation awards $7.1 million to help Flint families

No 'smoking gun' against ex-state water chief in Flint crisis, lawyer says

All Stories

UM-Flint and MCC originally **notified students and staff of the testing in emails** sent out Tuesday, Jan. 13, the same day some residents staged a water quality protest at city hall and city council members hosted a town hall meeting about the issue.

In December, the state Department of Environmental Quality found the city in violation of federal standards for excess trihalomethane, or TTHM. Flint sent out notices to all water customers saying that over many years, the byproduct could cause certain health problems.

Although Flint and DEQ officials have said the water is safe to drink, a citywide notice told residents with "a severely compromised immune system, (who) have an infant or are elderly" that they may be at increased risk from drinking water with high TTHM levels and should seek advice about drinking the water from a health care provider.

The notice also says people who drink water with TTHM in excess of the maximum contaminant level over many years may experience problems with their liver, kidneys or central nervous system and have an increased risk of getting cancer.

That notice caused MCC and UM-Flint to do their own testing.

Overall, Lane said he's happy to see the results of the water testing, especially with the TTHM levels being acceptable.

"We didn't know what the results were going to be and we were pleased to see that the water coming to our buildings were acceptable. But we're going to continue to monitor it, probably do another test in the next four weeks," Lane said. "The important thing here is that we are doing testing from time to time, whether quarterly or monthly.

"We're committed to making sure the people on the campus are safe. ... We were pleased to see the results come back the way they have."

An email was sent on Jan. 24 to the UM-Flint campus community saying the results (including trihalomethanes or THMs) were below the Maximum Contaminant Limits (MCLs). Then on Friday, Feb. 6, the email was expanded to include the lead levels at the two locations.

A second round and third round of testing of Northbank Center South building kitchen sinks and fountains took place to continue looking for the root of the problem.

"Results from some of the initial water draws showed an elevated lead concentration. However, after water was flushed/purged through the fixtures sample results were either non-detect or below the lead action level, with only one exception," the Jan. 24 email stated. "The results from sinks and fountains that were identified as seldom or rarely used which allows for water to sit for long periods of time, had the highest observed concentrations."

A third round of "first draw" sampling was conducted last week on drinking fountains and kitchen sinks on the first, second and third floors in Northbank Center South building. Although, more than half of the sample results were below the lead action level, the third floor hallway fountains and second floor sinks continue to show elevated lead concentrations and will require further action and corrective measures, the email stated.

Kitchen sinks and fountains being investigated /tested have and will remain tagged out of service "Do Not Use/Water Sampling In Progress" until further data is available and the investigation of the water distribution system in those areas is complete.

"Until further notice and until more data is available, NBC South building occupants impacted by this situation have been cautioned to flush water prior to use, only use the water for cleaning purposes and not for consumption, do not use restroom sinks for drinking water, and do not use sinks or fountains that remain tagged out of service," the email stated.

The water issue has been gaining a lot of attention throughout Flint and beyond. There have been multiple protests and community meetings. There have been free bottled water give-a-ways and a Flint Head Start program began only using bottled water.

Environmental activist Erin Brockovich spoke out and said she was prepared to come to Flint if needed.

A water expert working for environmental activist Erin Brockovich is **planning a trip to Flint to take part in a Feb. 14 public demonstration** for clean water.

MCC officials said they would be **testing the water early this month** and UM-Flint officials said they will continue to test the water that is used on campus every four to six weeks and monitor any changes or trends.

If there are any issues that are found as a result of the testing, that information will be communicated to the UM-Flint campus, according to a Jan. 24 email.

EXHIBIT U

From: Kelly Rossman-McKinney [krossman@truscottrossman.com]
Sent: Monday, February 09, 2015 3:36 PM
To: Nicholas, Robert
CC: David Gadis; Edwards, Scott; Matt Demo; Whitmore, Paul
Subject: RE: FW: Help with a Flint Journal article

Thanks, Rob. I knew the THM levels would likely be up this summer. Didn't know about the flow of water issue at the university and glad you have this on your radar screen.

From: Nicholas, Robert [mailto:robert.nicholas@veolia.com]
Sent: Monday, February 09, 2015 3:34 PM
To: Kelly Rossman-McKinney
Cc: David Gadis; Edwards, Scott; Matt Demo; Whitmore, Paul
Subject: Re: FW: Help with a Flint Journal article

Kelly

Do not pass this on.

This begins to prove our concern that with lots of different people doing tests it is a problem unless clear information is provided.

Flow of water in different parts of the building is the schools responsibility. The City however needs to be aware of this problem with lead and operate the system to minimize this as much as possible and consider the impact in future plans. We had already identified that as something to be reviewed.

Likewise the THM may have been safe for that one sample but that is not how non compliance is evaluated by the State and EPA. The testing is based on a rolling average of four quarterly tests and not a single test. The tests should be good this winter. Its likely to be higher in the summer.

On 9 February 2015 at 14:41, Kelly Rossman-McKinney <krossman@truscottrossman.com> wrote:

> Proving what Rob and I just were discussing ... EVERYONE is testing that darn water!
>
> **From:** Jason Lorenz [mailto:jlorenz@cityofflint.com]
> **Sent:** Monday, February 09, 2015 2:11 PM
> **To:** Kelly Rossman-McKinney
> **Cc:** Howard Croft; Elizabeth Murphy; Gerald Ambrose
> **Subject:** Fwd: Help with a Flint Journal article
>
> Hello Everyone,
>
> Here is another water related story that I believe can be deflected. It appears U-M Flint has done water testing on their campus recently. The tests came back showing TTHM levels were lower than MCL, but have shown in a few places higher than acceptable lead levels. Is this an internal plumbing issue that is not connected to us? Please advise.
>
> Thanks,
>
> -Jason Lorenz
> Public Information Officer
> City of Flint
> (810) 237-2039

jlorenz@cityofflint.com

---------- Forwarded message ----------
From: **Schuch, Sarah** <SSCHUCH@mlive.com>
Date: Mon, Feb 9, 2015 at 12:39 PM
Subject: Help with a Flint Journal article
To: "jlorenz@cityofflint.com" <jlorenz@cityofflint.com>

Hi Jason,
I'm working on a story about an email that was sent out to the UM-Flint campus community on Friday about their water quality. I was hoping to get comment on if any of it seems related to the issues with Flint water or if it's an isolated incident. They saw high levels of lead in certain locations. I will copy the email below this.

Would someone be able to comment on this today?

Dear Campus Community

Environment, Health, and Safety (EHS) has received a few inquiries about my recent January 24th e-mail communication. To help further clarify the status of water conditions, the raw analytical results (including trihalomethanes or THMs) provided by an independent consultant demonstrated that the City of Flint water entering our campus water distribution is below the regulatory Maximum Contaminant Limits (MCLs) and acceptable to drink.

However, in the first round of sampling there were two isolated fountains within two separate buildings where the test data initially showed poor water quality. EHS shut down those fountains, retested and continues to investigate. The two fountain locations were the third floor Northbank Center (NBC) South building hallway and the Central Energy Plant on the first floor.

A second round of testing of NBC South building kitchen sinks and fountains consisted of an initial water sample drawn followed by a second sample drawn after the water was flushed and purged through the fixtures. Results from some of the initial water draws showed an elevated lead concentration. However, after water was flushed/purged through the fixtures sample results were either non-detect or below the lead action level, with only one exception. The results from sinks and fountains that were identified as seldom or rarely used which allows for water to sit for long periods of time, had the highest observed concentrations. A third round of "first draw" sampling was conducted last week on drinking fountains and kitchen sinks on the first, second and third floors in NBC South Building. Although, more than half of the sample results were below the lead action level, the third floor hallway fountains and second floor sinks continue to show elevated lead concentrations and will require further action and corrective measures. Kitchen sinks and fountains being investigated /tested have and will remain tagged out of service "Do Not Use/Water Sampling In Progress" until further data is available and the investigation of the water distribution system in those areas is complete.

Until further notice and until more data is available, NBC South building occupants impacted by this

situation have been cautioned to flush water prior to use, only use the water for cleaning purposes and not for consumption, do not use restroom sinks for drinking water, and do not use sinks or fountains that remain tagged out of service. NBC Management and EHS have worked with impacted offices to identify alternative drinking water sources.

EHS & Facilities & Operations continue to investigate the water distribution in the building. The analytical data as well as further insight into the condition and configuration of the piping in NBC South will be helpful to better understand the conditions and determine best corrective measures for the areas observed to have poor water quality.

As always, if you have further questions please do not hesitate to contact me, EHS: 810-766-6763; or mjlane@umflint.edu<mailto:mjlane@umflint.edu>.

Mike Lane

UM-Flint Environment, Health, and Safety

Sarah Schuch
MLive Media Group
Reporter

mobile 810.341.3789
email sschuch@mlive.com
address 540 S. Saginaw St. #101, Flint MI 48502

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Rob Nicholas
Vice President, Development
Municipal & Commercial Business
VEOLIA NORTH AMERICA

tel

+1 859 582 0104

5071 Endview Pass / Brooksville, FL 34601
Robert.Nicholas@veolia.com
www.veolianorthamerica.com

EXHIBIT V

From: Nicholas, Robert [robert.nicholas@veolia.com]
Sent: Monday, February 09, 2015 3:35 PM
To: Marvin Gnagy
Subject: Fwd: FW: Help with a Flint Journal article

Yep. Lead seems to be a problem.

---------- Forwarded message ----------
From: **Kelly Rossman-McKinney** <krossman@truscottrossman.com>
Date: 9 February 2015 at 14:41
Subject: FW: Help with a Flint Journal article
To: David Gadis <david.gadis@veolia.com>, "Nicholas, Robert" <robert.nicholas@veolia.com>, "Edwards, Scott" <scott.edwards@veolia.com>, Matt Demo <matt.demo@veolia.com>, "Whitmore, Paul" <paul.whitmore@veolia.com>

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Thanks,

-Jason Lorenz

Public Information Officer

City of Flint

(810) 237-2039

jlorenz@cityofflint.com

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As always, if you have further questions please do not hesitate to contact me, EHS: 810-766-6763; or mjlane@umflint.edu<mailto:mjlane@umflint.edu>.

Mike Lane

UM-Flint Environment, Health, and Safety

Sarah Schuch

MLive Media Group

Reporter

mobile 810.341.3789

email sschuch@mlive.com

address 540 S. Saginaw St. #101, Flint MI 48502

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www.veolianorthamerica.com

Resourcing the world VEOLIA

EXHIBIT W

Gerald Ambrose
Emergency Manager

Dayne Walling
Mayor

Jason Lorenz
Public Information Officer
(810) 237-2039
jlorenz@cityofflint.com

For Immediate Release

Flint Hires International Urban Water Experts of Veolia North America to Assess City's Water Issues

Flint, Michigan – February 10, 2015 – The City of Flint has retained a team of urban water experts from Veolia North America to conduct an analysis of the city's water system. Veolia, which is the world's largest water services and technology company, will assess how Flint's water is tested and distributed, including reviewing water treatment processes and operations, laboratory testing and analysis, and engineering reports that detail the city's treatment and distribution systems.

"We understand the frustration and urgency in Flint," said David Gadis, vice president of Veolia North America's Municipal & Commercial Business. "We are honored to support your community with our technical expertise so that together we can ensure water quality for the people of the city of Flint."

Veolia anticipates its analysis to take less than two weeks, at which time they will present findings to City officials, including the Mayor, City Council and the Emergency Manager. Once the findings are presented, city officials will determine how to move forward.

"Addressing the City's water challenges are the top priority right now and it is important to bring in an independent, highly qualified team to work with us to address the safety and quality issues," said Mayor Dayne Walling.

–CONTINUE–

Gerald Ambrose
Emergency Manager

Dayne Walling
Mayor

"Until we have completed our analysis, we cannot say for certain how long it will take to provide solutions to Flint's current water situation," said Gadis. "We have extensive experience handling challenging river water sources, reducing leaks and contaminants and in managing discolored water."

"Veolia worked diligently to respond to our Request For Proposal in a thorough, professional way and demonstrated the ability to immediately support us as we ensure safe, clean water for our residents," said Emergency Manager Jerry Ambrose.

The Veolia team hit the ground running Tuesday morning, meeting with water officials to provide an overview of the work to be conducted. "We look forward to helping Flint's team find ways to address and improve the city's drinking water operation," Gadis said.

The company designs and provides water, waste and energy management solutions to communities and industries across the country, including providing water and wastewater services to 530 communities in North America. More information is available at www.veolianorthamerica.com.

–END–

City Hall
1101 S. Saginaw Street - Flint, Michigan 48502
810-766-7346 FAX: 810-766-7218 www.cityofflint.com

EXHIBIT X

VEOLIA WATER

VEOLIA NORTH AMERICA
6708 Denbridge Drive
Sylvania, Ohio 43560
www.veoliawaterna.com

Tel : 419.450.2931
Fax:
Mobile : 419.450.2931

Weekly Summary of Activities

From: Marvin Gnagy
To: Joe Nasuta
Date: February 12, 2015
Subject: Weekly summary
cc:

1. **Hours Worked**

Hours Spent	Project Location or Activity
[redacted]	
24	Flint, Michigan THM issues
	Expense reports
	Vacation
40	Total
	SUMMARY
	BD work related to new projects
	PPS (sales support- prior to award)
3	PPS (Implementation/operations support)
	COGS
	Account Management (Existing contract scope expansion or renewal/extension support)

2. **Major COGS Items**
   a. None.

3. **Major BD Support Items**

a. Flint, Michigan – Conducted data reviews, plant evaluations, and lab data collection, interviews with staff, observations of process treatment, etc. for Flint, Michigan. Discussed plant operations with city engineering firm, plant staff, and distribution supervisor to get an idea of how things are operated and controlled. Reviewed several sets of plans related to original design and plant upgrades that have been constructed or are being constructed for the treatment plant. Several observation shave already been noted. There is no process control, plant operators are not well trained, data is not well managed or trended, just reported to the state, ozone and lime appear to be overdosed, ferric chloride appears to be severely underdosed. Numerous distribution valves are broken shot changing water flows and increasing water age in the system. System storage is severely oversized for plant operations. Many of the system pipelines are 60 years old or more and consist of old cast iron unlined water mains. Developed a plan for jar testing evaluations and TOC profiling for next week. Obtained lab equipment and chemicals for jar testing and prepare forms and other evaluations tolls for jar testing. Depin and I will be in Flint all week the 16th.

b. [redacted]

c.

4. **Other Major Support Items**
   a. None.

Upcoming Tentative Schedules
February 16th – Flint
February 23rd – Camden, NJ
March 2nd – Flint and Camden data evaluations from home
March 9th – Flint and Camden follow-up?
March 16th – Flint and Camden follow-up?
March 23rd - Pittsburgh

5. **General Comments**
   a. None.

EXHIBIT Y

From: Fahey, William [william.fahey@veolia.com]
Sent: Friday, February 13, 2015 5:10 PM
To: Joseph Nasuta
CC: Kevin Hagerty
Subject: Re: Flint

Go on record with BD that we should advise Flint to open the valve from Detroit if we believe that is the best technical solution. DO NOT let BD make any technical calls. PLEASE. ..this will come back and bite us.

On Feb 13, 2015 5:03 PM, "Nasuta, Joseph" <joseph.nasuta@veolia.com> wrote:

> Just talked with Marvin. BD is driving this and Marvin thinks Rob N is now looking at doing a Power Point presentation sometime next week based on what he and Theping have found this week. Marvin and Theping are there next week doing TOC profile through the plant and jar testing on various treatment schemes. Both of my guys are saying that there is not process control and poor operations are the issue. They plan to only do a report of the results of their jar tests. Not sure what BD is trying to sell. Marvin thinks there will only be a Power Point presentation to Flint by BD and no long technical reporting.
>
> I understand what Bill is saying and we always try to be technical and not political. Both Marvin and I said "what about Detroit" when this came up but I understand BD (Rob N and David G) is saying it will not have any impact. Here is a bit from what Theping said regarding what is happening there:
>
> - it was made clear by the City during our first kickoff phone call that reconnecting to DWSD (as an interim method) is not an option. The reason often cited is $12M/yr additional cost.
> - The City has invested about $48M in upgrades for the WTP to treat the river water since 2000. The City has been on the path of treating its own water for long time. The breakup with DWSD was not amiable, and City officials have resisted the calls from some council members and residents to reconnect to DWSD water. It becomes both political and financial issues.
> - famous activist Erin Brockovich sent a "water expert" to participate in a protest tomorrow in Flint, and he is touring the plant with Mayor today. He has already said prior to arrival that "the Flint problem is fixable with tweaks", most likely after learning Veolia is on board.
> - our scope includes recommendation for operation and process improvement. There will be price tags associated with some of the process improvements which may aid the City to make decision if it wants to reconnect.
>
> Based on my conversation with Marvin, the plant is capable of treating the water if run correctly and with a few changes, Flint has no intention of going back to DWSD due to the money invested in their water plant to date and the cost of buying water, and in two years they will be on Lake Huron water which will eliminate the TOC issues they are now facing. So we will most likely not end up with a long term O&M but I'm not sure what is being sold to Flint other than this short consulting job.
>
> Joe
>
> On Fri, Feb 13, 2015 at 12:41 PM, Kevin Hagerty <kevin.hagerty@veolia.com> wrote:
>
>> Understood.
>>
>> Joe - When is the report going to be generated for this project?
>>
>> **From:** Fahey, William [mailto:william.fahey@veolia.com]
>> **Sent:** Friday, February 13, 2015 2:25 PM
>> **To:** Hagerty, Kevin; Joseph Nasuta
>> **Subject:** Flint

Kevin:

On the Flint MI project that Marvin is working on. If the best "technical decision is to go back to the City of Detroit as its supplier" we should not be afraid to make that call. Just make sure that the politics of this should not get in the way of making the best recommendation.

Bill Fahey

Senior Vice President-Technology
Municipal & Commercial Business
VEOLIA NORTH AMERICA

tel

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/ cell

+1 617 794 7616

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william.fahey@veolia.com
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Resourcing the world VEOLIA

--
Joseph T. Nasuta, PE
Director, Optimization
Municipal & Commercial Business
VEOLIA NORTH AMERICA

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Las Vegas, NV
joseph.nasuta@veolia.com
www.veolianorthamerica.com

Resourcing the world VEOLIA

EXHIBIT Z

Integrated Resource Management, Inc.

February 17, 2015

Honorable Mayor Dayne Walling
& Members of the City Council
1101 South Saginaw Street
Flint, Michigan 48502

RE: City of Flint Municipal Drinking Water System
Initial Water Quality Investigation and Water Rate Issues

Ladies and Gentlemen:

I would like to thank the Office of the Mayor and City Council Members for extending such a warm welcome to me on my recent visit to the City of Flint this past weekend. Flint, Michigan enjoys a wonderful history and is part of what has made America strong. Clearly, the City of Flint is a community in transition.

While my initial visit focused on the water supply and immediate concerns for the health and safety of the community water supply, the following recommendations are broader in scope and are meant to be purely constructive.

Source Supply Evaluation

- Update and implement the Source Water Protection Plan.
- Define and identify groundwater quality and quantity inflow variables to the Flint River, specifically from the contaminated sources identified adjacent to the river.
- Define and identify reservoir release surface water quality and quantity variables to the Flint River, specifically from the Holloway Reservoir.
- Thoroughly evaluate the Detroit Water Supply quality characteristics.
- Conduct a detailed "cost of treatment assessment" of the Flint River Water Treatment Plant and compare it directly to the cost per unit of water purchased from Detroit. Publish said results and allow for public input as to the choice of water supplied based upon actual costs versus quality.

405 North Indian Hill Boulevard
Claremont, CA 91711-4600
(909) 621-1266
(909) 621-1196 Fax

Water Treatment Plant

In order to achieve immediate improvement to the water quality in the City of Flint, the following recommendations should be considered for implementation. Said recommendations are made with the intent of being migratory toward ultimate treatment of Lake Huron water from the Karegnondi Water Authority.

- Optimize the ozone disinfection system.
- Discontinue the use of sodium bisulfate to reduce pH in the ozone contact chamber.
- Trust the Plant Operator to use the optimum amount of ferric chloride required for coagulation.
- Investigate the use (jar tests) of ferric chloride and various water treatment polymers to reduce the use of corrosive ferric chloride.
- Discontinue the practice of lime softening. Continue the flow through the softener facility and consider adding a low dose of filter aid (additional polymer) as necessary during seasonal high turbidity.
- Discontinue the practice of fluoridation.
- Discontinue the practice of recarbonation.
- Discontinue the use of pre-filtration chlorine.
- Remove the anthracite coal media from the filter beds and replace it with a granular activated carbon (GAC) material. There are specifically engineered products for use in dual media filters. The use of GAC for organic Trihalomethanes (THM) precursor removal will immediately reduce THM formation in the drinking water supply.
- Post chlorinate disinfect based on residual demand requirements. Post chlorination will not be as intensive as the organic material will be dramatically reduced. The GAC will also serve as a barrier to other types of contamination events (petroleum, chemical, and algae blooms).

Distribution System Operations

- Complete development of the water distribution hydraulic flow model.
- Immediately increase distribution system velocities.
- Re-engineer the distribution system to encourage directional sediment transport for evacuation of system contaminates (sludge, biofilm, sediment, and other debris). This will further aid in chlorine demand management.

- Take at least one of the water system storage reservoirs out of service. Thoroughly clean the storage reservoir, perhaps a program of alternative years of service. With the 2 MG elevated tank, perhaps both reservoirs could be removed from service this year.

Budget & Rate Concerns

I have extremely limited information on the rate-setting program. My recommendations here are more about a process that aids communities with transparency. I have been advised to look at a recent study by one of the local colleges; further, I would need access to a detailed budget and expenditure accounting to provide more specific recommendations.

- Prepare a budget that accounts for all fixed/variable debts: loans, capital depreciation of infrastructure, retirement system obligations, etcetera. This will allow the community to understand exactly where it stands in relation to its debt obligations… before one drop of water is produced. The total of the compilation can then be divided among the consumers based on number and class size of services. It is simple, straightforward, and easily understood.

- Prepare a budget that accounts for all commodity/variable costs: salaries, chemicals, energy, contract services, etcetera. This will allow the community to understand exactly where it stands as it relates to the cost of water. Using historic production and sales numbers, project a water sales figure and divide the commodity costs among the units; this is the true cost of water.

Again, this recommendation letter is very limited in scope. I will continue to make myself available to you and members of the community to answer questions.

The City of Flint, while consulting with the Michigan Department of Environmental Quality, must begin to set its own parameters for compliance with the Safe Drinking Water Act. You have a very well qualified staff at the Flint River Surface Water Treatment Plant and they need to be given the latitude and flexibility to get the job done. I am not in anyway advocating violation of the Safe Drinking Water Act… indeed the recommendations I have made should help bring the City of Flint closer to the actual spirit of compliance as opposed to just meeting the statutory requirements.

Respectfully,

Bob Bowcock
Integrated Resource Management, Inc.

cc: Erin Brockovich
Melissa Mays
Pastor Alfred Harris
Howard Croft

EXHIBIT AA

VEOLIA

City of Flint, MI
City Council Public Works Committee

Interim Water Quality Report

Veolia Scope of Work

Week 1

- Provide a review of current actions
- Engage staff, visit facilities and analyze data
- Make interim report

Week 2

- Carry out more detailed study of initial findings
- Make recommendations for Improving water quality
- Provide a plan, cost and schedule for change

Items of Note

- **Not in scope** – studying why the change from DWSD or the history of the utility
- **What we found** – A very frustrated community and a staff trying to solve the problem, having some success but frustrated with the pace of change

Everybody Is Checking the Safety of Water

- City, state, news media, universities and other groups
- Safe = compliance with state and federal standards and required testing
  - *Latest tests show water is in compliance with drinking water standards*
  - *Monthly report available on web page*
- More than 20,000 tests required annually for city
- Strict testing requirements in place (what and how to test)

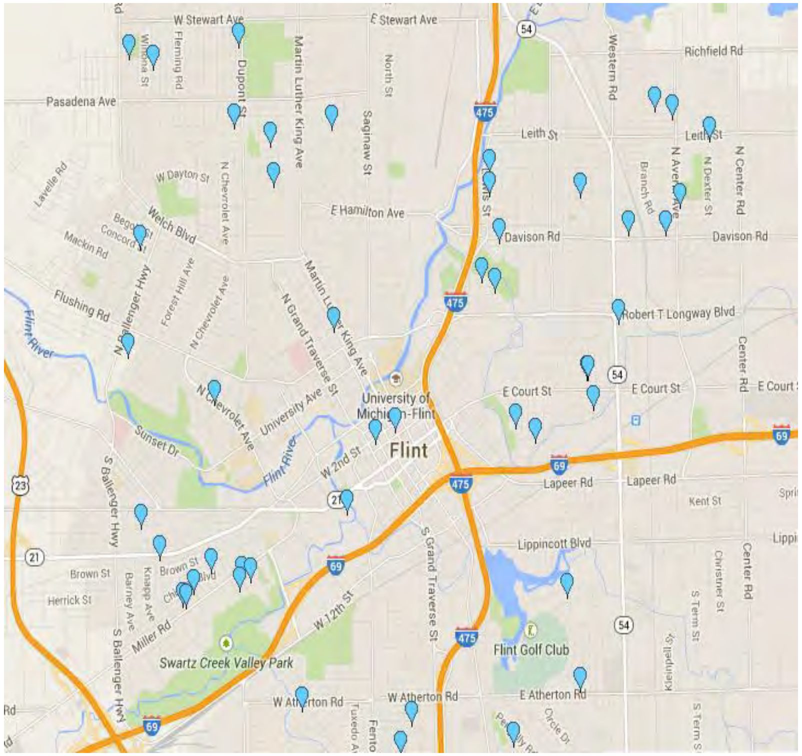
Why TTHM Notices?

- TTHM is formed as a result of the reaction between chlorine and organic material in the water
- City is required to test quarterly at 8 sites
  - *Last summer, several sites had more TTHM than allowed*
- City has reduced levels of TTHM and now all sites are in compliance
  - *Customer notification letters are required until tests are in compliance an average of four quarters*
- It will take at least 2 more quarters to lower average
  - *Even a change to DWSD water doesn't solve problem*
- Flint is not alone – hundreds of communities are facing TTHM issues

Why Discolored Water?

- Old cast iron pipes
- Always has been some discolored water problems – mostly after water breaks
- Efforts to reducing TTHM didn't help discoloration
  - *Doesn't mean the water is unsafe but it is not appealing and raises questions*
- City will test the water at your home – call 787-6537 or email flintwater@cityofflint.com
- Tracking customer complaints is important

Location of water quality complaints
The last 12 months – fewer than you think



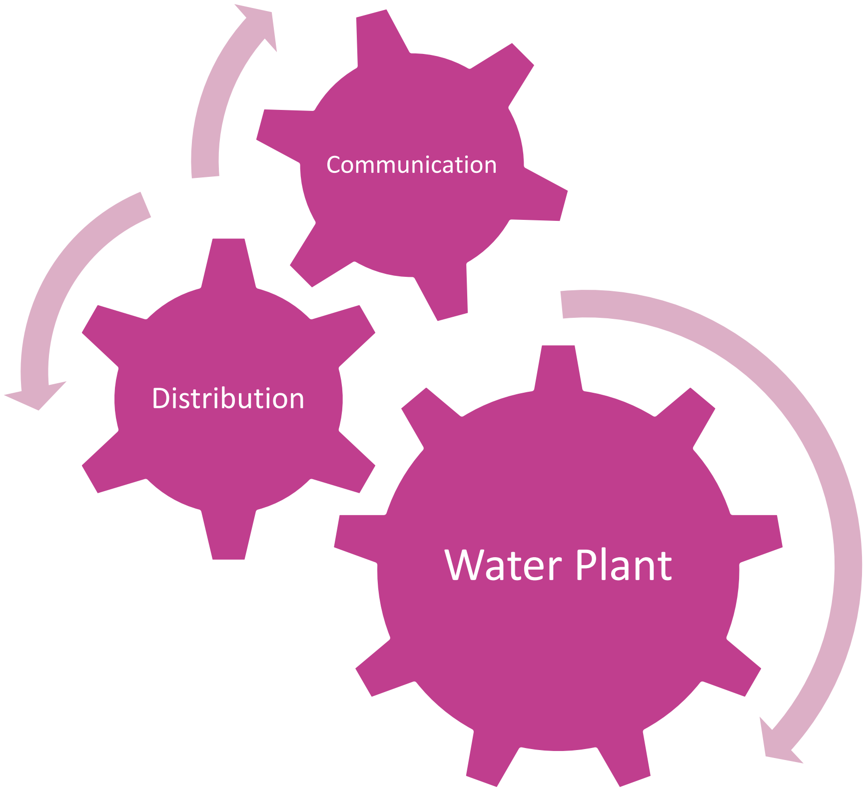
Water Quality Can Be Improved

- Adjust the chemicals being fed – stop some, increase some and change some
- Provide better monitoring of water quality to help make adjustments
- Continue repair or replacement of broken parts
- Reduce the over capacity of the distribution system
- Do a better job explaining what is happening
- Do a better job of asking for help

VEOLIA

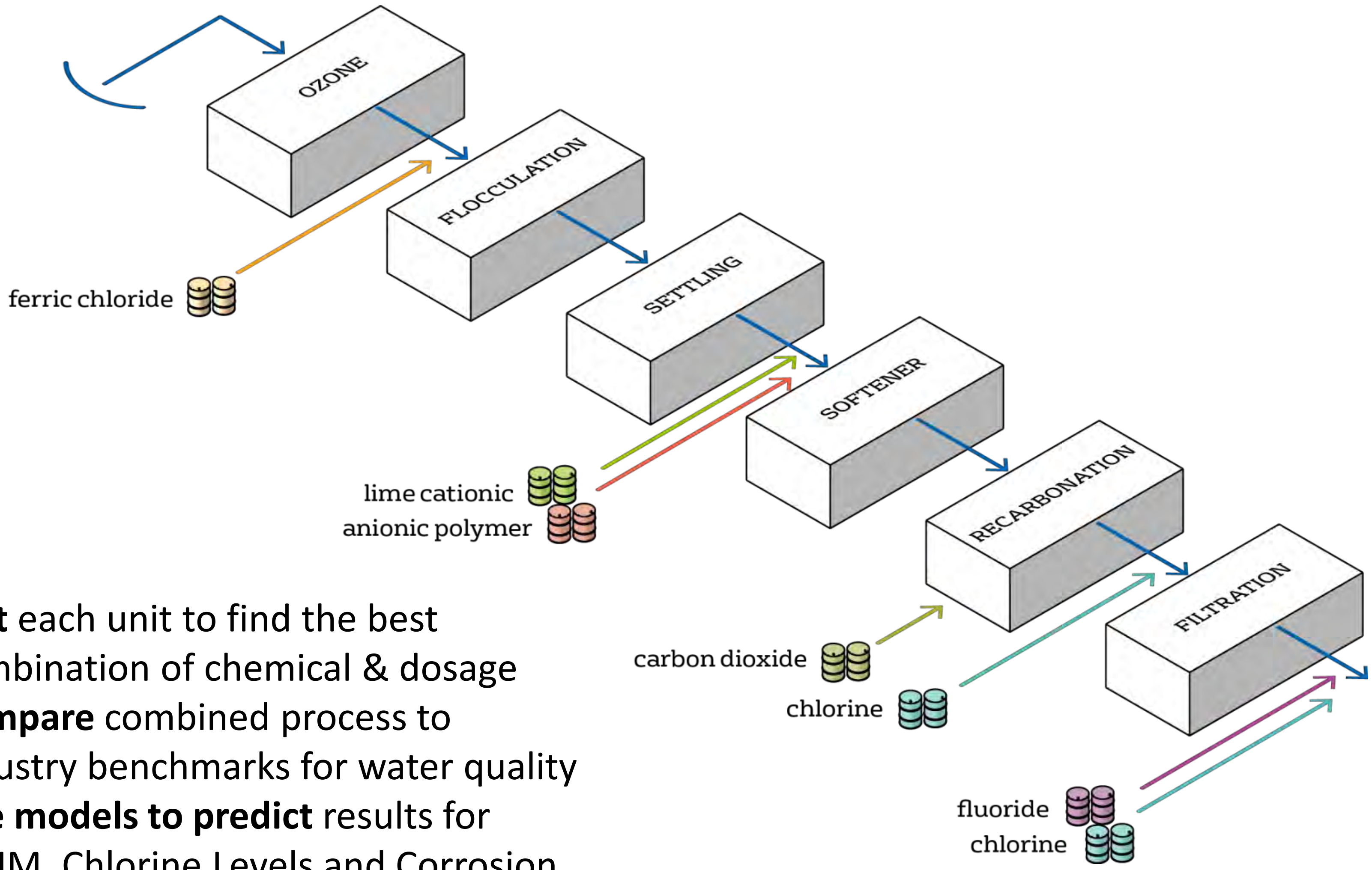
Further Explanation of Solutions

Solution Involves Coordination of 3 Activities



- Water plant improvements
  - *Optimize chemical dosages*
  - *Consider different chemicals*
  - *Change dosing points*
  - *Install granulated activated carbon*
  - *Complete plant upgrades*
  - *Implement best mgt practices*
- Distribution system improvements
  - *Fix broken valves*
  - *Ask for customer feedback*
  - *Reduce tank storage*
  - *Target line flushing*
  - *Run a hydraulic model*
- Better communication with customers
  - *Engage advisory committees*
  - *More accessible utility*
  - *Make it easy to access information*
  - *Better customer communication*

Optimize Plant Processes



- **Test** each unit to find the best combination of chemical & dosage
- **Compare** combined process to industry benchmarks for water quality
- **Use models to predict** results for TTHM, Chlorine Levels and Corrosion

Complete Plant Construction & Re Prioritize Capital

Cost effective plan in budget

- Complete water plant renovation
  - *Target SCADA and instrumentation in plant*
- Speed up valve turning contract & provide money for replacements
- Speed up hydraulic model update to reduce tank volume
- Evaluate installing of granulated activated carbon on filters

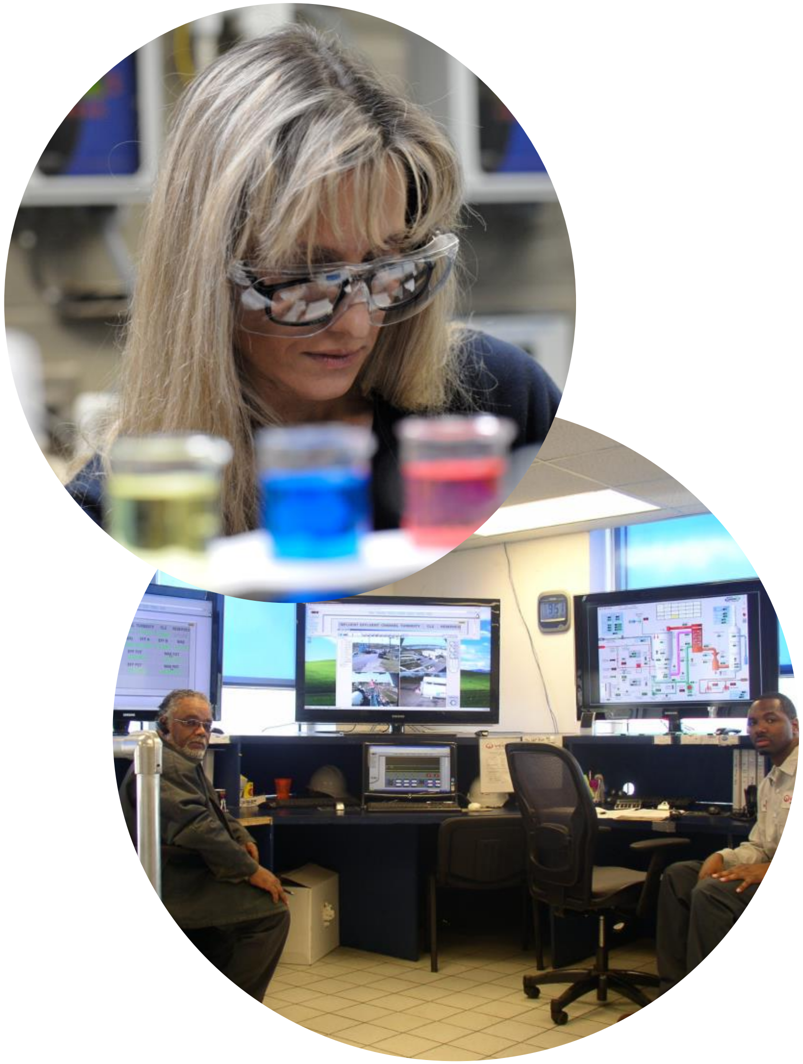
Weather can impact timing

Digging up a water valve for repair
Need good weather to start

Implement Best Management Practices

<u>Activities to Help Operators Maintain Good Water Quality</u>

- Process Control Management Plan
- Lab QA/QC Program
- Computerized Maintenance Management System
- Asset Management System
- Training and Certification Program
- Vulnerability Plan



Distribution System Improvements

- Speed up flow of water from plant to homes – 2 weeks plant to house
  - *Find closed valves & open them*
  - *Replace broken valves*
  - *Update hydraulic model*
  - *Reduce system storage*
- Track customer complaints
  - *Test customer water*
  - *Spot flush hydrants to clean areas of stagnant water in the system*

Flushing out discolored water

Improving Customer Service

Make It Easy to Access Information and People

Develop a proactive customer communication plan

- Create advisory committees to help direct efforts and improve flow of information
- Establish a single point of contact to manage all water quality complaints
- Provide additional customer service training to staff
- Expand neighborhood and community outreach
- Change monthly billing statements from card to envelope with information

Example - Communicate in the field

NOTICE: ANNUAL FLUSHING PROGRAM

We are conducting our annual flushing program to enhance your water quality and clean the distribution system.

DC Water crews will be flushing hydrants in your area 10:00 p.m. to 6:30 a.m. on the following dates:

9/24 **through** 9/30

IMPORTANT INFORMATION

- Your water supply will not be shut off during hydrant flushing.
- You may notice slight water discoloration or low water pressure.
- During this time, customers can continue normal water usage, including drinking, bathing and laundry (unless water is discolored).

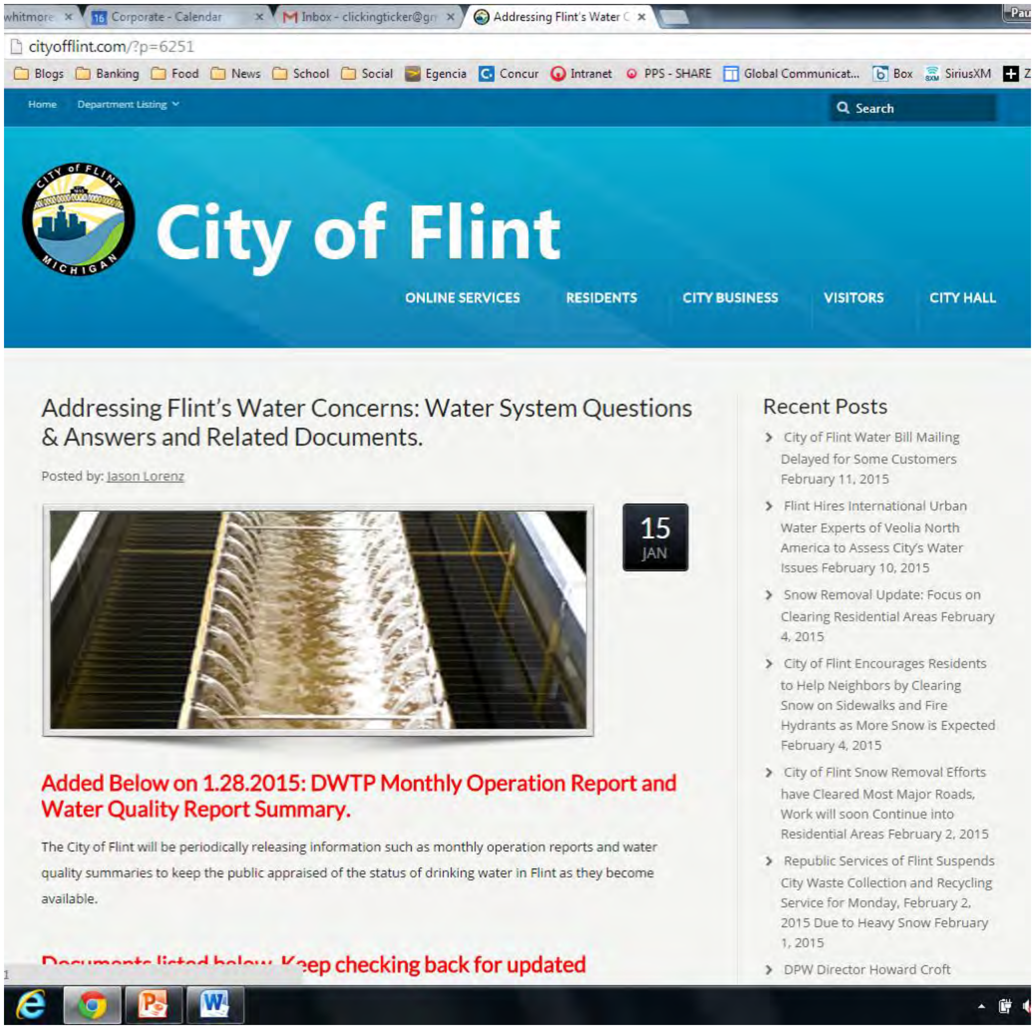
If you experience discolored water during this period:

- Run your cold water taps for 15 minutes. If it does not clear up, please contact our Drinking Water Division.
- Do not run your hot water. If you experience discolored water from your hot water tap for several hours, then it is recommended to drain and flush your water heater tank.

- **Provide field crews with additional communications tools to use to address questions or concerns from the public**
  - ***Create door hangers, flyers, or yard signs to notify neighborhoods about main breaks, hydrant flushing, or system maintenance that may affect the public***
  - ***Create a business card or other contact card with the name and phone number of the single point of contact with the Department of Public Works who is managing information flow***

  - ****sample door hanger provided by DC Water & Sewer Authority***

Clear, concise information is key



- **Simplify the reports on the web page dedicated to addressing water system questions**
  - ***Create a single-page, easy to understand report for the public***
  - ***Use charts or provide other examples to demonstrate water quality testing and system or treatment plant improvements underway***
  - ***Provide name, phone number and email address for identified point of contact so customers can request more information***
  - ***Continue to provide Monthly Operation Report and Water Quality Report Summary for those customers interested in more technical information***
  - ***Use site to provide additional notice of field work that may impact customers***

What Is Next

Next Steps

Week 1

- Provide a review of current actions
- Engage staff, visit facilities and analyze data
- Make interim report

Week 2

- Carry out more detailed study of initial findings
- Make recommendations for Improving water quality
- Provide a plan, cost and schedule for change

Questions Being Heard

REMEMBER

We just started. Might not have an answer yet to your question

- **When will water improve -** The water has improved with current actions. More changes will occur over weeks and months because of safety reviews
- **Date of next update and final report** – An update will be provided next week and a report the following week.
- **Time frame for implementing recommendations –** The City is already started. Others a few days and some weeks or months due to State approval being required or weather.
- **Cost of changes** – Don't know yet but we are aware of the financial concerns

More Questions Being Heard

- **How are TTHM formed –** It's the reaction of chlorine to organics (leafs, dirt) in the water.
- **How to reduce TTHM –** Reduce organics before introducing chlorine and shorten time chlorine has to react with the organics
- **What causes discoloration –** Older lines, the iron parts of the system will leach iron into the water causing the discoloration. Other times its just air built up.
- **Why no discoloration with DWSD –** There was. Flint had a bad time with breaks of old line and is doing lots of construction. This stirred up the water and caused discoloration.

More Questions Being Heard

- **Can you test my water –** The city will test your water for free. But, only 2 of 20 people have taken the city up on the offer since it began offering the service.
- **Medical problems –** Some people may be sensitive to any water. Talk to your doctor. The City is communicating with the medical community.
- **Confidence that future problems will be avoided** – Recommendations will include putting programs in place to better respond to water changes and assure quality

Questions?

EXHIBIT BB

Despite quality problems, 'Your water is safe,' says Flint consultant

Updated Feb 19, 2015;
Posted Feb 19, 2015

20

Gallery: Water consultant meets with City Council for update

Comment

0
shares

By Ron Fonger | rfonger1@mlive.com

(This story has been updated to correct the amount of the consulting contract between Flint and Veolia.)

FLINT, MI -- A city consultant says Flint has problems with sediment and discoloration in its water but it is safe to drink and currently meeting all state and federal standards.

Officials for Veolia North America gave that initial assessment Wednesday, Feb. 18, but several members of the City Council were unconvinced and said the report amounted to little more than a sugar coating on deep problems.

"The city has reduced levels of TTHM, and now all (testing) sites are in compliance," said Rob Nicholas, vice president for Veolia, the consultant that city officials introduced during a news conference just last week. "(The problems) are less about the water itself and more about the (transmission pipes)."

Veolia officials said they expect to issue a more formal, final report and recommendations in two weeks but said it's likely to

include recommendations on adjusting how much and what kind of chemicals the plant uses.

Nicholas said the city needs upgrades in its distribution system, fixes in how it's communicating with the public and additional investments at Flint's water treatment plant.

The consultant didn't estimate costs or detail specific changes, but some council members said they were disappointed by what they've heard so far.

"I will not tell any of the residents I represent to drink the water," said Councilman Kerry Nelson. "You cannot come in here and tell this community it's OK ... It's not OK with me."

Council members said they continue to hear complaints from residents about differences in the taste, smell and color of drinking water since the city began using the Flint River as its source in April.

Councilwoman Jackie Poplar said she's using bottled water to wash her face because chlorine levels are bothering her skin since the switch.

The switch to the Flint River as a source of drinking water came after 50 years of the city buying water that comes from from Lake Huron, treated by the Detroit Water and Sewerage Department.

By mid-2016, the city is expected to start receiving raw water from Lake Huron through the Karegnondi Water Authority pipeline that's currently under construction.

Councilman Eric Mays said Veolia officials can say recent test results have improved but not that the river water is safe.

Flint remains in violation of the Safe Drinking Water Act because total trihalomethane (TTHM) levels were so elevated in 2014, and Mays said the chemicals needed to treat river water could be part of the reason cast iron pipes are producing more sediment than they did when lake water was flowing.

"I thought I would hear (today of) a time for when we will get good water," said Mays, who called the report "doubletalk."

"When there's no more notices (of violation) -- then and only then can you sit and tell me the water is safe," he said.

Nicholas said hundreds of communities around the country are dealing with water quality issues like Flint. Problems with old pipes that make up the city's transmission system mean some of those issues will continue whether Flint uses Lake Huron or the Flint River.

"It's less about the water itself and more about the pipes," he said. "You're just getting debris flushed out of the pipes ... You don't want to drink it because it looks bad."

Some pieces of the initial report from Veolia were similar to a letter issued this week by Bob Bowcock, a water expert who works with environmentalist Erin Brockovich.

Both Nicholas and Bowcock raised the possibility, for example, for the city to replace the anthracite coal media from filter beds at its treatment plant with a granular, activated carbon material.

Both also suggested changes in the chemicals being used to treat river water and the timing of that treatment.

Emergency manager Jerry Ambrose said he appreciates the work Veolia has done so far.

"We are committed to move forward, (and) the water quality is improved," Ambrose said.

Veolia is the world's largest water services and technology company. Its team started work in Flint last week and is being paid $40,000 to assess how city water is tested and distributed, including water treatment processes and operations, laboratory testing and analysis.

Ambrose hired the company after former emergency manager Darnell Earley started work on the request for proposals last month.

Earley said in January that the city had shown "some issues managing the supply" of public water since April.

EXHIBIT CC

City of Flint Email

Howard Croft <hcroft@cityofflint.com>

Leanne Walters - 212 Browning

5 messages

Michael Glasgow <mglasgow@cityofflint.com> Tue, Feb 24, 2015 at 1:48 PM
To: Howard Croft <hcroft@cityofflint.com>, Daugherty Johnson <djohnson@cityofflint.com>, Robert Bincsik <rbincsik@cityofflint.com>, Brent Wright <bwright@cityofflint.com>

Gentlemen,

We have a new issue with 212 Browning. I was there last week (2/18) for a follow up to the sampling from the week before (2/11). Nothing had changed in regards to discoloration and high iron content. However I had Leanne collect a sample for Lead & Copper as part of our monitoring requirements for 2015. The results come back today and the level of lead was 104 ppb. The limit on lead is 15 ppb. In our previous round of lead and copper sampling in 2014, only 2 samples (out of 100) were above our limit of 15 ppb, with the highest values at 37 & 23 ppb. There is definitely a pressing issue here, and with this recent lead result and the previous iron results, she has some data to prove it. I will have her collect another lead and copper sample to validate or dismiss the original result. Lead can be found in many plumbing features including faucets, but I worry if her service line is lead. I will attempt to approach adjacent neighbors to see if the issue is only at her residence, or is spreading through the neighborhood (through iron testing at first). I have had no other calls or testing requests from the general area.

Mike

Robert Bincsik <rbincsik@cityofflint.com> Tue, Feb 24, 2015 at 2:19 PM
To: Michael Glasgow <mglasgow@cityofflint.com>
Cc: Howard Croft <hcroft@cityofflint.com>, Daugherty Johnson <djohnson@cityofflint.com>, Brent Wright <bwright@cityofflint.com>

The majority of service lines in the COF are lead from the main to the curb and in some cases from the main to the house. Marvin from Veolia mentioned to me he thought we needed to add phosphate to our water to help prevent this. Perhaps we need to move on this sooner rather than later given we have approximately 80% lead service lines and 1000's of leaded joints.
[Quoted text hidden]
--
Thank you,

Robert Bincsik
Water Distribution and
Sewer Maintenance Supervisor
City of Flint
3310 E. Court Street
Flint, MI 48506
Ph: 810.766.7202 ext. 3413
Fx: 810.743.5758

Howard Croft <hcroft@cityofflint.com> Tue, Feb 24, 2015 at 2:26 PM
To: Robert Bincsik <rbincsik@cityofflint.com>
Cc: Michael Glasgow <mglasgow@cityofflint.com>, Daugherty Johnson <djohnson@cityofflint.com>, Brent Wright <bwright@cityofflint.com>

Yes,

Move quickly to isolate this to the service line if possible. I would check as many of the neighbors as possible and practical.

[Quoted text hidden]

--

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Public Works Director
City of Flint
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Flint, MI 48502
PH# 810.766.7135 Ext.2043
hcroft@cityofflint.com

Robert Bincsik <rbincsik@cityofflint.com> Tue, Feb 24, 2015 at 4:10 PM
To: Howard Croft <hcroft@cityofflint.com>
Cc: Michael Glasgow <mglasgow@cityofflint.com>, Daugherty Johnson <djohnson@cityofflint.com>, Brent Wright <bwright@cityofflint.com>

I think this indicates a larger potential problem in the system. If this one service is showing lead issues the entire system could begin to show these problems.

[Quoted text hidden]

Michael Glasgow <mglasgow@cityofflint.com> Wed, Feb 25, 2015 at 8:45 AM
To: Robert Bincsik <rbincsik@cityofflint.com>, Brent Wright <bwright@cityofflint.com>, Daugherty Johnson <djohnson@cityofflint.com>, Howard Croft <hcroft@cityofflint.com>

I'm not sure I would rush to say this will be seen in the entire system, we have only seen an issue < 3% of samples out of the last few months (103 samples total). Most treatment plants calculate the Langelier Index to give a general idea of the "aggressiveness" of the water. Our index usually runs on the positive, which means the water should be scale forming and not corrosive. We are required to perform testing of 25 sample sites each quarter for pH, calcium, alkalinity, temperature, and conductivity. These values are then used to calculate the "aggressiveness" of the water. I wish we could fix our problems with a corrosion inhibitor, but I'm not sure that is the case. Also, most inhibitors are phosphate based, which may come to haunt us in the summer months as phosphate is an energy source for biological growth.

[Quoted text hidden]

EXHIBIT DD

From: Edwards, Scott [scott.edwards@veolia.com]
Sent: Thursday, February 19, 2015 10:47 PM
To: Whitmore, Paul
CC: Karole Colangelo
Subject: Re: INTERNAL ONLY - CONFIDENTIAL Flint Situation

Thanks, Paul. Or... an emergency manager, with a nod from the mayor, city admin, and key council members gives us a nod to take on a $15-30M/year O&M contract. Or a Buffalo type job. Keep that close. We'll see where these guys land. Karole - Bill is apparently getting informed from Mike.

Let's all stay close.

Scott

On Thu, Feb 19, 2015 at 7:38 PM, Whitmore, Paul <paul.whitmore@veolia.com> wrote:

> Here is a quick rundown of the environment in Flint. My version of a risk memo.
>
> -Emergency manager who hired us leaves in April, replaced by a city administrator with a very, very high salary - already controversial
>
> -It's likely the EM will try and hurry up a new contract with us before he leaves
>
> -Mayor is up for re-election this year
>
> -Mayoral primary August 4. General election November 3
>
> -The city council is dysfunctional, many with questionable backgrounds
>
> -One or two are expected to run and could quite possibly win
>
> -One of them, Wantwaz Davis, has been holding water marches and protests
>
> -The council wants immediate action. We've been there one week and that's already too long and the council is restless.
>
> -One of the councillors last night was holding up something from FWW (or another group) highlighting Richmond/Baykeepers, Angelton TX, and a VES overbilling lawsuit/settlement in Minn.
>
> -The city is in violation of TTHM and will be for the foreseeable future. Another notice will go out in mid-March, followed by another in June.
>
> -The city is nearly bankrupt and it's very bleak - whatever they would pay us would probably be more than it would cost to "just reconnect to Detroit."
>
> -Residents are already paying $150 month for water and sewer (hiring us might raise even more issues)
>
> -They're digging a giant new pipeline to Lake Huron. They'll join a new water authority when the pipe is finished, and change water sources - causing another round of issues in the plant and distribution system.
>
> In the perfect storm (read St. Louis) the person who hires us will no longer be there to defend the decision to hire us and there becomes pressure to get rid of us. We become a part of the mayor's race between the current mayor who likes and wants us, and the likely challenger from

the council not seeing fast enough action. The council already has researched us and pulled some material - they'll keep going if they need to.

So, this reads really bad. It's a true picture of what's happening and what risks we face: Being dragged into another St. Louis - like political fight, in a community that is restless, poor, angry, frustrated, scared and lacks trust in their leaders and their water utility.

Happy to discuss further. Seemed easier to go this route so it's out there.

Paul

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--
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EXHIBIT EE

From: Nicholas, Robert [robert.nicholas@veolia.com]
Sent: Monday, February 23, 2015 5:42 PM
To: Gnagy, Marvin
CC: Joseph Nasuta; David Gadis
Subject: Re: Utilities Org Chart

You summed up pretty well the discussion Harald, mike, Dave and I had Thursday. The goal is to finish our report. I am done with TV.

On Monday, February 23, 2015, Gnagy, Marvin <marvin.gnagy@veolia.com> wrote:

> I was on late the call today (traveling issues) and have some concerns about Veolia working on a longer-term contract with Flint. Solely technical assistance is not typically what we provide on contracts for municipalities and I believe that is where we are headed with Flint. There is no money to be made there, we will just be providing expertise under a direct reimbursement until they obtain KWA source water.
>
> I have concerns about Veolia being insulated from the unreasonable Council and the public relations issues. If we place a manage there, I feel most of their time will be working out public relations problems and satisfying Council requests, not focusing only technical assistance and water quality compliance. If the manager has no more support than the Buffalo project, we likely will not be able to keep a manager on the Flint project. It needs to be clear in any contract that Veolia will not participate in public meetings or heated debates related to the long-remaining water quality issues. There is no way we can overcome decades of poor utility management and poor operations practices that have lead to the condition of the system as it is today.
>
> I don't believe they will be interested in implementation of management and quality-driven programs like PCMP, CMMS, operator training, etc. The information gathered to date only indicates to me they want the water quality issues(THM and colored water) to go away yesterday. We all know that will not happen.
>
> I have concerns related to whether the administration will follow through with any recommendations we provide. If not, we have provided no benefit whatsoever.
>
> I have concerns related to the verbal abuse we will get as soon as the next THM notices are mailed out and the questions start related to why Flint hired a water expert when we still have THM violations. This will happen time and time again over the next three quarters until they can find a way to reduce THMs below the regulatory limits and reporting.
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expertise and about us even being in the community.

My gut tells me to provide a report of our findings as we said we would and walk away from this one.

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On Mon, Feb 23, 2015 at 3:58 PM, Gnagy, Marvin <marvin.gnagy@veolia.com> wrote:

Is the increased production in 2014 over 2013 due to main breaks of poor metering?

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On Mon, Feb 23, 2015 at 3:32 PM, Nicholas, Robert <robert.nicholas@veolia.com> wrote:

---------- Forwarded message ----------
From: **Howard Croft** <hcroft@cityofflint.com>
Date: 23 February 2015 at 15:04
Subject: Re: Utilities Org Chart
To: "Nicholas, Robert" <robert.nicholas@veolia.com>

Rob,

Here is a trend chart that I put together that shows the water produced from the plant over the last two years.

On Mon, Feb 23, 2015 at 1:55 PM, Nicholas, Robert <robert.nicholas@veolia.com> wrote:

Thanks Howard

On 23 February 2015 at 10:07, Howard Croft <hcroft@cityofflint.com> wrote:

Rob,

Here is a look at a Utilities wide org. chart.

There are a total of 138 budgeted full time positions even though that is not specifically reflected on the chart.

--

Howard Croft
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EXHIBIT FF

From: Fahey, William [william.fahey@veolia.com]
Sent: Wednesday, February 25, 2015 6:28 PM
To: Kevin Hagerty
Subject: Re: FW: Utilities Org Chart

We never should have gone in the first place. I will look very closely at how much money we spent on this so I can use it against them on the next go/nogo call. All the reasons that Marvin lists in his email were discussed. Unreal

On Feb 25, 2015 6:10 PM, "Kevin Hagerty" <kevin.hagerty@veolia.com> wrote:

> This is the email from Marvin that I was talking about.
>
> ---
>
> **From:** Joseph Nasuta [mailto:joseph.nasuta@veolia.com]
> **Sent:** Monday, February 23, 2015 8:57 PM
> **To:** Kevin Hagerty
> **Subject:** Fwd: Utilities Org Chart
>
> FYI.
>
> Sent from my Corporate iPhone
>
> Begin forwarded message:
>
> > **From:** "Nicholas, Robert" <robert.nicholas@veolia.com>
> > **Date:** February 23, 2015 at 5:42:19 PM EST
> > **To:** "Gnagy, Marvin" <marvin.gnagy@veolia.com>
> > **Cc:** Joseph Nasuta <joseph.nasuta@veolia.com>, David Gadis <david.gadis@veolia.com>
> > **Subject: Re: Utilities Org Chart**
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EXHIBIT GG

Lockwood, Andrews & Newnam, Inc.
FINAL

Operational Evaluation Report

City of Flint

Trihalomethane Formation Concern

City of Flint, Michigan
1855

February 27, 2015

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

EXECUTIVE SUMMARY

Environmental Protection Agency (EPA) and Michigan Department of Environmental Quality (MDEQ) regulations require that public water suppliers test drinking water quarterly throughout the distribution system for disinfectant by-products (DBP's). Two categories of DBP's, tri-halomethanes (THM) and halo-acetic acids (HAA5), are regulated and must be tested for. The City of Flint began operation of their water treatment plant (WTP) full time with the Flint River as the source on April 25, 2014. Since that time, four quarters of samples taken have resulted in an annual average violation for total THM. Prior to the first violation (Nov. 2014), the City hired Lockwood, Andrews & Newnam, Inc. (LAN) to complete this Operational Evaluation Report (OER) in conformance with EPA guidelines with the goal to determine the cause(s) of high levels of THM and evaluate possible solutions.

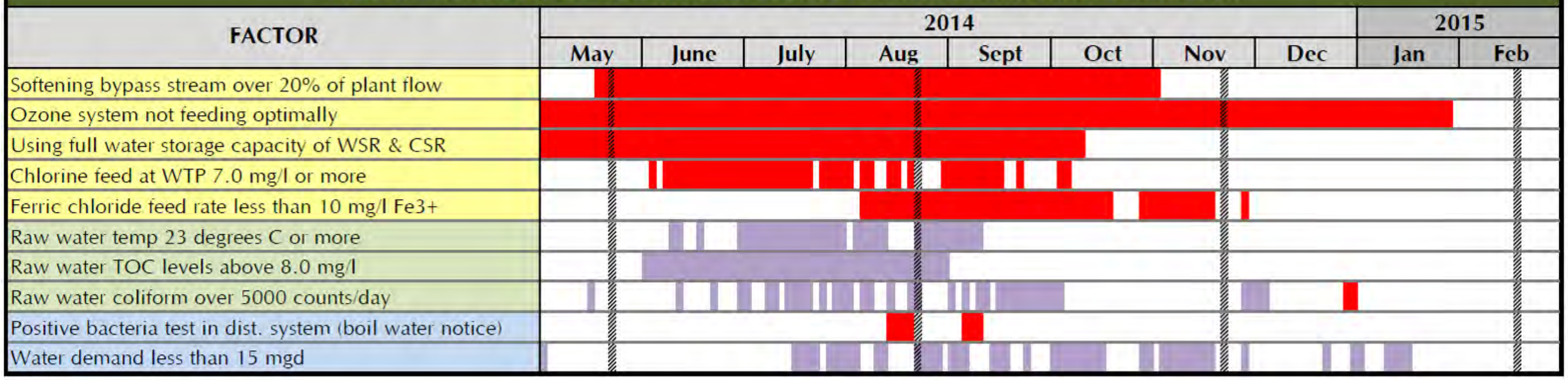
The EPA promulgated the Stage 2 Disinfectants and Disinfection By-Products Rule (DBPR) in January 2006 which set maximum contaminant levels (MCLs) for total trihalomethanes (TTHM) and HAA5 based on an annual running average, tested quarterly, for a given sampling location. The City of Flint reports levels from 8 sampling test locations. Of the four quarterly sampling cycles since Flint began operating the WTP full time, HAA5 levels have been acceptable but TTHM levels were high at 4 sampling sites following the third sampling cycle. Average THM levels exceeded the MCL at 3 sites following the fourth sampling cycle.

A number of issues have been identified as possibly contributing to the high THM levels measured.

1. Inefficient ozone system functionality which has resulted in increased chlorine feed.
2. Upstream source influences in terms of increased chlorine demand.
3. Bypass stream around softening contributed to chlorine demand and increased total organic carbon (TOC) levels in the effluent.
4. Unlined cast iron pipes in the distribution system contributing to chlorine demand.
5. High water age in the distribution system due to:
    a. Broken valves causing less than ideal flow patterns.
    b. Inefficient pump station pressure zones
    c. Water storage volumes in excess of that needed for today's demands
    d. Oversized water mains
    e. Low water demands
6. High chlorine demand in filters.
7. High THM formation potential (THMFP) in source water.
8. Less than optimal removal of THM precursors

A graphical representation of how the factors above relate to the timing of THM compliance sampling is shown as Table 1. Compliance sampling dates are hatched. Each row in Table 1 describes a factor than can lead to increased THM levels and the table defines when each of those factors applied. Note the convergence of nearly all factors around the second sampling period on August 21, 2014 to create what appears to be a worst case scenario. The table also shows that the factors listed as those that the City can control have been addressed prior to the February sampling period. Monthly operating report data up to February 1,2015 is depicted on the Table.

TABLE 1 - SUMMARY OF NEGATIVE INFLUENCES ON THM COMPLIANCE SAMPLING



Dates of occurrence
Dates of occurrence and expected to repeat in future years
Compliance sampling date

Factors under Flint staff control
Flint River characteristics
System factors

ACTION PLAN

The City of Flint has signed an agreement with the Karegnondi Water Authority (KWA) to purchase raw water drawn from Lake Huron. The KWA system is currently under construction and expected to be operational by late 2016. The water supply from Lake Huron will have entirely different water quality characteristics from the Flint River and those characteristics are expected to yield drastically reduced DPB formation. With that, non-structural options to help reduce THM levels are much preferred over solutions requiring new construction. Therefore, two categories of actions have been devised: Stage 1 being actions that can be completed relatively quickly without major construction and Stage 2 consisting of either long term actions or solutions requiring major construction. The City is actively working to complete Stage 1 actions as soon as possible. Stage 2 actions are to be implemented only if Stage 1 actions are ineffective in adequately reducing TTHM levels and therefore Stage 2 is contingent upon the outcome of Stage 1. As of the date of this report, status updates for action items are shown in red.

Stage 1 – Immediate Actions

- Hire third party water quality expert to complete independent 'water audit'
  - The City hired Veolia Water to review all water quality related operations, procedures, actions taken and planned responses. Recommendations from Veolia are expected by the first week in March 2015.
- Obtain an in house THM analyzer to allow regular operational monitoring of THM levels
  - THM analyzer was installed 2/17/15.
- Hire ozone system manufacturer to troubleshoot ozone system
  - Manufacturer and controls programmers performed on site evaluations in January 2015.
- Bench scale jar testing
  - Match existing process and assess possible areas of improvement
    - Existing process was simulated and an evaluation of existing chemical feed dosages has been completed by LAN.
    - Existing process TOC profile was developed by Veolia.
  - Simulate potential modifications to treatment process
    - Soda ash softening evaluation completed and PAC feed testing completed by LAN.
  - Evaluate coagulation and flocculation polymer aid feeds to assist with TOC removal
    - Evaluations of polymer aids completed by LAN and PVS Technologies.
- WTP operational changes
  - Discontinue softening bypass stream to reduce chlorine demand
    - Operational directive has been set to soften no less than 80% of flow.
  - Disinfection of filter beds to reduce chlorine demand
    - Utility Service Group contracted by City and condition assessment completed. Controls improvements have been completed.
  - Begin coagulation and flocculation polymer aid feeds to assist with TOC removal if bench scale test results are positive
    - Jar testing completed to date has not indicated a useful benefit to feeding coagulation/flocculation polymer aids. Increased ferric doses have been implemented at the WTP based on positive jar test results.

- Increase water main flushing efforts to minimize stagnant water
  - Flushing efforts are ongoing as weather permits.
- Water system modeling to identify areas with high water age and potential solutions
  - The water model has been improved and preliminary results, including system wide water age, have been produced. Water demand updates and reconciliation with operator's data are scheduled for March 2015 to complete water modeling analysis.
  - Cedar Street Pump Station potential recirculation
    - Water model analysis to be completed in March 2015.
  - West Side Pump Station potential recirculation
    - Water model analysis to be completed in March 2015.
  - Storage tank volume use
    - Operating levels of West Side and Cedar Street reservoirs have been lowered to reduce water age
  - Possible broken closed valve locations
    - Model has been updated with known broken valve locations. Model results are being evaluated for indications of other possible broken valves. City has also initiated valve assessment program.
  - Locations in need of flushing
    - High water age areas have been identified in the water model. Further evaluation forthcoming to determine most effective flushing points.

Stage 2 – Contingent Actions

- Fix ozone system
  - Repairs have been made to gauges and programming and the system is producing proper ozone and functioning under manual operation. Further minor repairs are planned for the 1st quarter 2015 to allow automatic operation.
- Start feeding coagulation and flocculation polymer aids to lower TOC, if not completed in Stage 1
  - Polymers evaluated by LAN did not demonstrate notable benefit.
  - PVS Technologies evaluated a proprietary polymer that showed little benefit.
- Convert to lime and soda ash softening
  - Cost effective analysis to be developed, if necessary, based on routine operation THM level monitoring.
- Change disinfectant to chloramine or chlorine dioxide until KWA
  - Cost effective analysis to be developed, if necessary, based on routine operation THM level monitoring.
- Install pre-oxidant feed at intake to optimize ozone disinfection
  - Permanganate feed at intake was evaluated by Veolia the week of 2/16/15 and recommendations are expected by the first week in March 2015.
- Replace filter media with granular activated carbon (GAC) media
  - Cost effective analysis to be developed, if necessary, based on routine operation THM level monitoring.
- Implement advanced treatment for THM precursor removal
  - Cost effective analysis to be developed, if necessary, based on routine operation THM level monitoring.
- Increased main flushing based on water modeling results
  - Water model analysis to be completed in March 2015.

- Continue valve replacements with water model assistance
  - Water model analysis to be completed in March 2015.
- Emphasize cast iron pipes on water main replacement priority list
  - Flint has bid replacement of over 2 miles of 24" cast iron pipe along Dupont and Bishop Streets to be completed this coming construction season. The water main section is considered a critical transmission main, and is expected to contribute to decreases in water age when complete

THM samples have been taken and tested 5 times since the City began using the Flint River for supply. Four sets of samples were taken for official regulatory compliance and one set of samples was taken by the City for operational monitoring. Samples were taken in May 2014, August 2014, November 2014, January 2015, and February 2015. THM levels at all sample sites have declined from August 2014 to February 2015. The average of all sample sites in August was 142.1 ug/l and the most recent average of samples taken in February 2015 was 19.8 ug/l. The MCL defined by the EPA is 80 ug/l.

I. BACKGROUND

The City of Detroit Water and Sewer Department (DWSD) has historically provided drinking water for the City of Flint and Genesee County. In the late 1990's growing concern regarding the reliability of the DWSD supply prompted the City of Flint to upgrade their existing water treatment plant (WTP). Those improvements, defined as Phase I, were completed in 2005 and were intended to allow the Flint WTP to operate, using the Flint River as the source, for an extended period of time in the event that supply from the DWSD was temporarily interrupted. Additionally, the Phase I improvements set the stage for Flint to break free from dependence on the DWSD supply and water charges over which they had no control.

A. WATER SUPPLY TRANSITION

1. Detroit Water and Sewer Department (DWSD)

Until recently the Genesee County and Flint region had been provided drinking water by the DWSD. However, due to excessive cost increases and reliability issues with the DWSD system other options had to be explored.

2. Karegnondi Water Authority (KWA)

In 2010 the Karegnondi Water Authority (KWA) was formed for the purpose of developing a new water supply from Lake Huron to serve the region in lieu of the DWSD supply and the City of Flint elected to join. The KWA expects the new system which is currently being constructed to become operational by the fall of 2016.

3. Flint River – Interim Period

With a renewing water supply agreement between Flint and the DWSD being terminated by the DWSD (effective April 30, 2014) and the KWA system not expected to be operational until late 2016, the City of Flint decided to initiate operation of the existing WTP full time utilizing the Flint River as the interim water source. A variety of WTP improvements were necessary for the Flint plant to become a full time plant. For purposes of this report, Phase II improvements to the Flint WTP are improvements intended to allow the plant to operate full time with either the Flint River as the source or the KWA supply as the source.

B. TTHM VIOLATIONS

The EPA and MDEQ method of determining if TTHM sample results exceed the MCL uses a locational running annual average (LRAA). Flint's first TTHM violation was cited by the MDEQ following the third cycle of sampling completed in November 2014. Of the 8 sampling sites, 4 were in violation. At that time the MDEQ used the following calculation for determining if the MCL had been violated:

(2 x current quarter value + previous 2 quarter values) / 4 = Operational Evaluation Value

Flint has now completed tests for 4 quarters and a straight annual running average applies. Based on samples taken on February 17, 2015 the number of sites in violation of the THM MCL limit has decreased to three. The City also conducted a round of sampling on January 27, 2015 in order to internally monitor the progress of actions taken to address the THM issue. It is worth noting that each round of sampling since August of 2014 has indicated a significant drop (improvement) in THM levels. Test results are tabulated in Table 2. HAA5 sample results are shown in Table 3, of which Flint has had no violations.

TABLE 2 – TTHM TEST RESULTS (ug/L)						
Sample Location	1st Qrt 5/21/14	2nd Qrt 8/21/14	3rd Qrt 11/21/14	Inter. 1/27/15	4rth Qrt 2/17/15	LRAA
WTP Tap	56	86	33	16	-	na
1) 3719 Davison McDonalds	162.4	145.3	58.6	35	16.2	95.6
2) 822 S. Dort Hwy BP Gas Sta.	111.6	112.0	36.2	23	19.9	69.9
3) 3302 S. Dort Hwy Liquor Palace	96.5	127.2	33.3	23	16.8	68.5
4) 3606 Corunna Taco Bell	106.4	181.3	33.9	24	18.1	84.9
5) 2501 Flushing Univ. Market	75.1	196.2	93.6	35	24.5	97.4
6) 3216 MLK Salem Housing	82.2	112.4	50.1	33	28.5	68.3
7) 5018 Clio Rite Aid	88.2	144.4	53.6	29	19.2	76.4
8) 6204 N. Saginaw N. Flint Auto	79.2	118.3	41.1	21	14.9	63.4

TTHM MCL = 80 ug/l

TABLE 3 – HAA5 TEST RESULTS (ug/L)						
Sample Location	1st Qrt 5/21/14	2nd Qrt 8/21/14	3rd Qrt 11/21/14	Inter. 1/27/15	4rth Qrt 2/17/15	LRAA
WTP Tap	36 (taken June 14, 2014)					na
1) 3719 Davison McDonalds	64	43	16	Na	9.0	33.0
2) 822 S. Dort Hwy BP Gas Sta.	52	40	21	Na	9.0	30.5
3) 3302 S. Dort Hwy Liquor Palace	48	31	15	Na	9.0	25.8
4) 3606 Corunna Taco Bell	55	24	15	Na	9.0	25.8
5) 2501 Flushing Univ. Market	38	17	24	Na	9.0	22.0
6) 3216 MLK Salem Housing	41	25	5	Na	2.0	18.3
7) 5018 Clio Rite Aid	49	30	17	Na	9.0	26.3
8) 6204 N. Saginaw N. Flint Auto	50	37	18	Na	9.0	28.5

HAA5 MCL = 60 ug/l

C. WATER TREATMENT PLANT RECENT IMPROVEMENTS & STATUS

1. Phase I WTP Improvements

Since 1965, the Flint WTP has remained a secondary or backup supply system to the DWSD primary supply. Typically the secondary supply for a public water system is expected to be needed only during emergency situations and normally is designed for short term operation such as providing the average daily demand for a few days. Conversely, Phase I improvements were designed with the intent to upgrade the Flint WTP in order to allow for an extended short term period (6 weeks) because of the perceived high risk that the DWSD supply would fail and remain out of service for an

extended duration. Regardless, the Flint WTP was still intended to serve as a standby plant and as such the Phase I improvements lacked redundancies that would be required for a primary supply WTP.

2. Past Pilot Study & Testing
During design of the Phase I improvements a treatability study was completed by Alvord, Burdick & Howson, LLC (AB&H) in 2002. The Treatability Study evaluated the current treatment processes that are in place at the Flint WTP today with the Flint River as the source. The report recommended the following:

TABLE 4 – 2002 WTP TREATMENT RECOMMENDATIONS

Treatment	Purpose	Point of Application	Dosage (mg/l)
Sodium permanganate	Zebra mussel control	Intake	0.3
Ozone	Taste & odor removal, disinfection	Diffusor basin	1.5
Ferric chloride	Coagulation	Rapid mix	40
Coag aid polymer	Turbidity & TOC removal	Rapid mix	2.0
Floc aid polymer	Turbidity & TOC removal	Floc basin	0.05
Lime	Softening	Softening basin	175
Soda ash	Softening	Softening basin	52
Carbon dioxide	pH adjustment	Recarb basin	37
Media filters	Filtration	N/A	Na
Chlorine	Disinfection	Filter effluent	1.0

Of the recommended items, zebra mussel control, coagulant and flocculation polymer aids, and soda ash feed have not been incorporated into the treatment process.

3. Phase II WTP Improvements for Full Time Operation
Phase II WTP improvements are those needed to convert the Flint WTP from a back-up supply to a primary supply plant. A number of improvements have already been constructed as they were necessary to operate full time when treating water from the Flint River. The improvements under the title of Phase II that have been completed or are nearly complete include installation of the future raw water feed connection point and valving for the KWA supply, upgrades to the lime sludge lagoon, the lime sludge lagoon decant and disposal system, decant pump station and force main, installation of mid-point chlorination before filtration, and upgrade of the electric feed sub-station.

Additional improvements to the Flint WTP that are to be completed to become part of the normal treatment process using water supplied by the KWA are:

- New oxygen and nitrogen storage facilities for the ozone system (under construction)
- New coagulant feed system
- Electrical
  - Pump Station #4 upgrades (under construction)
  - SCADA and controls upgrades
  - Filter transfer pump station feeders
- Pump replacements and VFD installation in the low and high service pump station (under construction)
- Filter transfer pump station to Dort Reservoir
- Facility security improvements

II. SOURCE WATER EVALUATION

A. DATA ANALYSIS

Based on past data collected and the 2002 Treatability Study by AB&H, the Flint River water quality varies seasonally with higher hardness and alkalinity experienced in the winter. Higher magnesium concentrations are also experienced in the winter, adding difficulty to the settling process due to neutrally buoyant floc. General water quality average characteristics recorded for the 2002 Treatability Study as compared with average characteristics recorded in 2014 are shown in Table 5 below.

TABLE 5 – FLINT RIVER WATER QUALITY CHARACTERISTICS

Period	Turbidity NTU	TOC Mg/l	Alk. Mg/l	Hardness Mg/l as CaCO3	pH	Total Col. Count/day	THMFP Mg/l
2001 Apr–Oct	7.9	9.4	215	272	8.1	870-1230 (7300 max)	410
2014 May–Oct	8.3	10.3 5/22/14	207	252	8.2	1900-9000 (48,300 max)	187

The Flint River characteristics do not appear to have changed significantly over the past 10+ years. Note that further investigation by City staff revealed a sewer leak upstream of the plant that may have contributed to the total Coliform count. The leak was subsequently repaired.

B. CONCLUSIONS

Considering the minor changes in Flint River water quality, much of the information contained in the 2002 Treatability Study by AB&H remains relevant today. Data from that report assumed to be consistent today include the following:

- Flint River is influenced by groundwater from a dolomitic aquifer
- Hardness varies seasonally with higher hardness and alkalinity in the winter
- Hardness, alkalinity, magnesium concentrations tend to be reduced by run-off

In development of the 2002 Treatability Study, processes were simulated which resulted in low THM levels. Therefore, information contained in that report will be used to assist with establishing a baseline jar testing procedure as discussed further in Section **III**.

III. TREATMENT PROCESS EVALUATION

A. EXISTING PROCESS DESCRIPTION

The existing WTP consists of an intake with screening from the Flint River, low lift pumping, ozonation, rapid mix, flocculation, settling, softening, recarbonation, filtration, storage and high service pumping. A process diagram is shown as Figure 1.

1. Intake

A 72" diameter pipe draws water from the Flint River through 2 traveling screens to the low lift pump structure. No chemicals are currently fed for Zebra mussel control or pre-oxidation as recommended by the 2002 Treatability Study. Manual removal of zebra mussels is more economical than installation of chemical feed equipment considering the short term need.

2. Ozone

There are 2 ozone generators designed to provide adequate ozone for a WTP flow of up to 36 mgd. There are 3 ozone contact basins. The ozone generators were designed to produce 900 lbs/day at 10% concentration and up to 1300 lbs/day at 6% concentration each. Prior to recent repairs, readings indicated a production rate of approximately 700 lbs/day at 4% concentration. It is possible that before the recent improvements the ozone feed might not have been optimized. In fact, it is known that less than optimal ozonation previously led to increased chlorine feed which would have contributed to THM formation.

3. Rapid Mix

East and West rapid mix chambers allow chemical feed prior to the flocculation basins. Each rapid mix chamber is equipped with a 5 hp mixer.

4. Coagulation / Flocculation

The WTP contains two equally sized flocculation basins, east and west, and each basin provides tapered or gradually slowed mixing from inlet to outlet. There are fifteen 2 hp mixers for each basin with VFDs to control mixing speed. The 2002 Treatability Study recommended feeding both coagulation and flocculation polymer aids. Neither polymer aid is being used today because turbidity and TOC removals have been sufficient to meet regulatory requirements.

5. Settling

Primary clarification takes place within 3 basins containing plate settlers. The settlers are operating as designed.

6. Softening

Again, there are two basins for softening: east and west. Each basin is 120' in diameter and contains a solids contact softening unit. Each softening basin/unit has a design capacity of 18 mgd. The east clarifier has an effluent weir imbalance that the City intends to fix when low demands allow for construction. Low lift pumping limitations, flow control to the basins, control restrictions on residuals removal, and fluctuating demands have made it difficult for WTP staff to stabilize the softening process. Softening is accomplished by feeding lime. The decision was made by the City not to feed soda ash in order to remove non-carbonate hardness because acceptable hardness levels could be achieved with lime feed only and softening is short term until Lake Huron water becomes available. Lime and soda ash softening is a possible consideration to assist with TOC removal and thus reduce THM formation.

7. Recarbonation

Recarbonation for pH adjustment is accomplished in east and west recarbonation basins between and to the north of the softening basins. Carbon dioxide storage and feed equipment is located west of the recarbonation basins.

8. Filtration

Filtration is accomplished with 12 dual media filters, equally sized and designed to filter 3.0 mgd each. Media consists of 12″ of sand and 18″ of anthracite. The filters have been operated intermittently over the years due to the standby nature of the WTP and until recently, chlorine injection took place downstream of the filters. It is possible some microbial growth had developed in the filters leading to increased chlorine demand. The City recently hired a contractor to upgrade the electrical controls for the filters and that work has been completed.

9. Disinfection

Disinfection is provided by ozonation and by feeding chlorine. Ozonation occurs at the front end of the WTP. Chlorine is fed prior to filtration and prior to finish water storage / high service pumping. The intermediate chlorine injection location was recently constructed under the Phase II, Segment 1 contract.

10. Clear Well & Pumping

The pump building sits adjacent to a 3 MG clear well and contains both low and high service pumps.

B. JAR TESTS / EXPERIMENTS

1. Approach

There are several well practiced methods by which DBPs can be reduced. First, the disinfectant can be changed to an alternate that has a lower tendency to form DBPs. Second, additional treatment systems such as activated carbon or air stripping (depending on the nature of the precursors) can be added to remove DBP precursors. Lastly, the existing treatment processes can be optimized to remove as much DBP precursor as possible. Of these options, optimizing existing treatment processes is the only strategy that does not require the construction of new and expensive facilities. It is anticipated that Flint will be receiving Lake Huron water in approximately two years and this water will have a completely different chemistry from the Flint River. Major process changes instituted to address THM levels using Flint River water are likely to be unnecessary for Lake Huron water and may even be inappropriate. Therefore, those options which require addition of new treatment processes are undesirable at this time. In recognition of this upcoming change in water source, efforts for this study have concentrated on improving the existing processes, rather than adding new ones. New treatment processes will only be recommended if operational changes to the existing treatment train prove ineffective.

Recent sample test results suggest that most of the DBPs are formed in the distribution system rather than within the treatment plant. Therefore, the most logical approach is to reduce the DBP formation potential (DBPFP) rather than simply lowering the levels of DBPs leaving the plant. During bench scale testing, formation potential (FP) levels were the primary indicator of success or failure of proposed process modifications.

2. Protocol

Bench scale pilot testing is intended to reflect actual plant operating and hydraulic conditions so the bench scale treatment units were sized based on various dimensionless factors to ensure the pilot treatment matched the actual system. Bench

scale ozonation was not practical due to time and cost limitations. Therefore, water samples were withdrawn from the plant ozone basin effluent. These samples were transported to the laboratory and dispensed into square testing jars. The jars were used to simulate rapid mix, three-stage flocculation, and settling. Rapid mix and flocculation conditions were matched to the plant based on "Gt" values. The "G" value is a measure of the mixing intensity and is a function of mix time, viscosity of the liquid, and mixing power applied to the water. "Gt" then, is a size scaling factor where time has been accounted for. Settling time was scaled to match the shorter settling depth of the testing jars. After settling, samples were decanted from the test jars. The decanted samples were then lime softened; softening conditions were similarly matched on the basis of "Gt". Carbon dioxide was sparged into the samples to reduce the pH. The water was then vacuum filtered through filter paper, sized to simulate the plant's dual media filters. The samples were dosed with excess chlorine and allowed to react for seven days at 25° C before testing for DBPs to determine the formation potential.

The following conditions were applied during testing to properly match small scale testing to actual plant processes.

TABLE 6 – BENCH SCALE TEST MIXING INTENSITIES

Process	G	Duration	Mix RPM
Ozonation	Plant	-	-
Rapid Mix	200	44 sec	160
Flocculation, Stage 1	50	9 min	55
Flocculation, Stage 1	25	9 min	30
Flocculation, Stage 1	12	9 min	19
Settling	N/A	10 min	-
Softening	TBD	10 min	-
Recarbonation	N/A	N/A	-

The primary variables during testing were chemical additions and chemical dosages. Specific chemicals and dosages used for initial testing conditions were selected to reflect current plant usage and the recommendations of the 2002 Treatability Study:

TABLE 7 – BENCH SCALE TEST CHEMICAL FEED RATES

Chemical	Current Usage	2002 Study	Test Values
Ozonation	4.66 mg/l	1.5 mg/l	
Ferric Chloride	7.7 mg/l Fe3+	40 mg/l Fe3+	7.7 – 80 mg/l Fe3+
Coagulant Aid Polymer	Not used	2.0 mg/l	1 – 2 mg/l
Flocculation Aid Polymer	Not used	0.05 mg/l	0 – 0.05 mg/l
Powdered Activated Carbon	Not used	N/A	20 – 100 mg/l
Lime	120 mg/l	175 mg/l	120 – 175 mg/l
Soda Ash	Not used	52 mg/l	0 – 52 mg/l
Cationic Softening Polymer	3.13 mg/l	Not used	3.13 mg/l
Anionic Softening Polymer	0.88 mg/l	Not used	0.88 mg/l
Fluoride	0.45 mg/l	1 mg/l	Not used
Carbon Dioxide	32 mg/l	37 mg/l	Fed to reach pH of 7.5 +- 0.3
Chlorine	6.3 mg/l	1 mg/l	10 mg/l

3. Considerations

The 2002 Treatability Study did not note significant formation of DBPs. This may be a function of different Flint River water chemistry at that time. However, recognizing the considerable differences in chemical usage and dosages between that study and current operations, those differences in chemical use and dosage are an obvious starting point for optimizing treatment to prevent DBP limit exceedance.

Although it is believed that optimization of current treatment can correct the DBP issue, should optimization of present treatment prove insufficient, alternate residual disinfectants (chloramines and chlorine dioxide) will be investigated as additional treatment measures.

4. LAN Test Results

Two rounds of jar testing were completed by LAN during the weeks of December 15, 2014 and January 26, 2015.Detailed test data is included in Appendix A. Testing results can be summarized as follows:

- Increased dosages of ferric chloride resulted in higher reduction of THMFP.
- The currently utilized feed rate of lime at 120 mg/l is appropriate
- Softening with soda ash in addition to lime resulted in minor additional THMFP reduction – in the range of 0% - 10%.
- The benefits of using a cationic polymer during softening at a dosage range of 0.31 - 3.13 mg/l to help reduce THM's are unclear
- The benefits of using an anionic polymer during softening at a dosage range of 0.09 – 0.88 mg/l to help reduce THM's are unclear
- Feeding PAC was ineffective in reducing THMFP within the dosage range of 20 – 100 mg/l.

5. Testing by Others

In addition to jar testing completed by LAN, the chemical supplier who provides ferric chloride for the City, PVS Technologies, ran tests using their recommended flocculant polymer aid. Plus, Veolia Water completed jars testing of their own the week of February 16th to analyze other process details and current WTP parameters. Experiments completed by PVS Technologies showed very little TOC removal beyond that obtained with straight ferric chloride feed.

6. Conclusions

Increasing the dose rate of ferric chloride is an operational change that can easily be implemented without the need for any additional equipment. Test results show that over 40% THMFP removal can be obtained with a dosage of 60 mg/l $Fe3+$ or higher. Increased dosing of ferric chloride would be most ideal coupled with regular raw water TOC monitoring so that TOC levels would dictate the appropriate ferric chloride feed rate.

Softening with soda ash in addition to lime is another option the City should consider if increased ferric chloride doses are not adequate to maintain THM levels under the MCL, particularly during warmer months. Again, monitoring of TOC in the raw water could provide useful information of when lime/soda ash softening is necessary.

IV. DISTRIBUTION SYSTEM EVALUATION

EPA guidance for the distribution evaluation portion of an OER is focused on identification and isolation of a specific portion of the distribution system that led to the exceedance. The circumstances of Flint's apparent pending TTHM exeedances are unusual in that a new supply has been implemented which clearly corresponds to the high TTHM sample results. Although the new source is one element in increased TTHM levels, value remains in evaluating the distribution system since water age is also a critical factor. Additionally, there may be distribution improvements that can be made to help alleviate the problem.

A. INFRASTRUCTURE

1. Piping

According to the most recent MDEQ Sanitary Survey, the distribution system is estimated to contain 70% cast iron, 20% ductile iron, 2% concrete and 8% steel water mains. Unlined cast iron pipe can become pitted, allowing colonization sites for microorganisms leading to chlorine demand. Additionally, much of the piping in the system is aged and in poor condition. Increased chlorine demand could be resulting from biofilm in older pipes and from main breaks/repairs. The extent of contribution is not known but any water main replacement project will decrease chlorine demand somewhat if constructed properly. Unfortunately, water main breaks may also assist with decreasing water age by providing unintentional flushing. All things considered, it is impossible to quantify the impact existing piping has on THM formation.

The City utilizes City Point software and GPS equipment to document main breaks and prioritize replacements. However, main break information is more pertinent to rusty water complaints and has little relevance to THM levels. Areas that have been targeted for main replacements include the transmission main from the WTP west to Dupont and south to the West Side reservoir, Fenton Road, Atherton Road, Dort Highway, Averil Street, and Boulevard Drive.

2. Storage

There are 4 finish water storage tanks and 1 raw water tank as tabulated below:

TABLE 8 – STORAGE TANKS

Name	Type	Water	Volume (MG)	Operating		Absolute	
				LWL	HWL	Bottom	OF
Dort Reservoir	Ground	Raw	20	-	-	730	750
WTP Tank	Elevated	Finished	2	883.0	896.0	863.0	898.0
WTP Clear Well – PS #4	Ground	Finished	3	11'	15'	708.5	726.0
Cedar Street Reservoir	Ground	Finished	20	-	11'	737.2	757.2
Westside Reservoir	Ground	Finished	12	-	12'	761.8	779.0

The MDEQ typically recommends providing a minimum finish water storage volume of 1/3 the maximum daily demand (MDD). According to the 2013 MDEQ Sanitary Survey, the 5 and 10 year MDDs are 21.57 mgd and 30.05 mgd respectively. A common rule of thumb for clear well storage volume at a WTP is 10% of the design flow rate. Another general guideline for reliability is to provide total storage to allow for 2 X the average daily demand plus fire flow demand. For this analysis, fire flow is assumed to be 2,500 gpm for either one industrial fire (2,500 gpm) or a combination of one residential (1,000 gpm) and one commercial (1,500 gpm) fire at a 4 hour duration which results in a total volume of 600,000 gallons. These go-by

approximations are summarized below with the applicable flow rates and are compared to the existing storage volumes currently being utilized.

Common Practice	Flow Rate	Recommended Volume by ROT	Volume In Use
Clear well 10% of Design Flow	18 MGD	1.8 MG	3.0 MG
Finish Storage = 1/3 MDD	30.05 MGD	10.0 MG	37 MG
Total Storage = 2 * ADD + FFD	13.87 MGD	28.3 MG	57 MG

Based on the values above, it appears the storage volume used in the Flint system could be decreased without negatively effecting reliability. The appropriate volumes of individual tanks will be further evaluated using the water system model and discussed in Section V (C).

All reservoirs have baffling to minimize stagnant water. Also, all tanks have been maintained and are in reasonable condition. The Westside reservoir has an exposed roof that is in need of rehabilitation, but its current condition has no influence on THM formation.

3. Pump Stations
All pump stations are in good condition but pumps are generally oversized. As an independent consideration, oversized pumps are not a contributing factor to high THM levels. Control of pumps and pressure zones are discussed in detail below.

B. OPERATIONS AND MAINTENANCE

1. Pump Station & Storage Operations
Pump stations and storage tank levels are controlled as shown in Table 9.

TABLE 9 – PUMP STATION CONTROLS

PS Name	Control Point	On Point	Off Point
PS No. 4 Raw	Operator	-	-
PS No. 4 Finish	Match plant flow	-	-
Westside	System pressure (elevated tank)	22.5′	33′
Cedar Street	System pressure (elevated tank)	22.5′	33′
Torrey Road	Distr. – Brown/Bradley	< 45 psi	> 45 psi

Cedar Street and Westside pump stations are operated as needed and they are alternated. Typically, Cedar Street is run in the morning and Westside is run in the evening and reservoirs for each are filled during low demand periods at night.

Westside, Cedar Street and Torrey Road pump stations are used to boost system pressure when high demands warrant it, but there are not well defined pressure zones within the system. Therefore, the possibility exists that water is being recirculated allowing for increased water age.

2. Booster Disinfection Practices
Booster disinfection is provided at the Cedar Street and Westside pump stations. When sustained residuals are not provided by chlorine feed at the WTP, sodium hypochlorite is applied at the reservoirs while being filled.

3. Changes in System Demands
Water demands in the City have been declining since the 1960's as the population has dropped. As a result, many of the water system components are oversized including storage tanks and water mains which both increase the time for water to reach the user.

From a short term perspective, Flint demands tend to increase in summer as is ordinarily expected but also in the winter due to water main breaks. The MDD for Flint often occurs in winter. Regarding THM formation, with lower temperatures and higher flows in the winter, THM levels taken at the distribution sample points are expected to be lower than at other times of the year.

C. WATER SYSTEM HYDRAULIC MODELING

As part of this report, the City provided a hydraulic water model, originally developed by Potter Consulting, for LAN to update. Thus far, LAN has modified the model to be capable of extended period simulations, modified controls to reflect current operations, revised the piping to include known broken valve locations, and developed preliminary water age results throughout the entire system. Water age shown in the updated model corresponds well to TTHM levels at 6 of the 8 sampling sites. However, LAN has also identified several deficiencies within the model that require further adjustments to allow for usable and reliable results. Those model deficiencies include outdated demands, improperly located appurtenances, and incorrect flow patterns. Preliminary water age results are presented in Table 10. Revised results will be provided when the hydraulic model has been fully updated.

TABLE 10 – PRELIMINARY WATER AGE FROM WATER MODEL

Sample Point	Location	Address	Water Age (Hrs)	Aug 2014 THM (ug/l)
1	McDonalds	3719 Davison	23	145
2	BP Gas Station	822 S. Dort Hwy	18	112
3	Liquor Palace	3302 S. Dort Hwy	15	127
4	Taco Bell	3606 Corunna	128	181
5	Univ. Market	2501 Flushing	178	196
6	Salem Housing	3216 MLK	50	112
7	Rite Aid	5018 Clio	78	144
8	N. Flint Auto	6204 N. Saginaw	71	118

It is anticipated that topics shown below in italicized font will be detailed after the model is updated in March 2015.

1. Simulation of Existing System
Match existing conditions. Chlorine and THM data may be used to verify model results. We have chlorine feed data at plant and residuals at 10 locations in each MOR, May 2014 – January 2015.

2. Identification of Water System Deficiencies
Specific issues to look at:

Worst case at minimum daily demands
Water age in entire system
Recirculating water through pump stations
Use of storage tanks – volumes in particular
Indications of broken valves
Effectiveness of booster disinfection

V. RECOMMENDATIONS TO MINIMIZE FUTURE OEL EXCEEDANCES

A. SOURCE

The City of Flint has already committed to the change from the Flint River as the water source to Lake Huron under the KWA system, planned for late 2016. The risk of future TTHM limit violations will decline substantially with the use of water from Lake Huron due to much lower DBP precursors. It is important to recognize that the Flint River will become strictly an emergency supply when the KWA supply becomes available and any investments toward the Flint River should be contemplated accordingly. Recommendations discussed below in this section apply to the Flint River as the source.

Reverting to supply from the DWSD until the KWA supply is available as an option. However, based on information provided by the City of Flint, the annual cost to receive water from the DWSD would be at least $16,000,000/year or $1,333,000/month. Therefore, utilizing the DWSD for interim supply is cost prohibitive under the terms defined by the DWSD.

1. Watershed Management

A volunteer group entitled the Watershed Coalition performs various tasks related to managing the Flint River watershed such as spring cleanups and annual benthic studies to evaluate the river 'health'. No additional action is recommended at this time.

2. Monitoring

The City documents daily raw water flow, pH, alkalinity, carbonate and non-carbonate hardness, chloride, temperature, turbidity and coliform count as part of standard preparation of Monthly Operating Reports (MOR). It is recommended to add raw water TOC and plant tap THM values to daily documented measurements which would provide staff the data needed to establish correlations to predict distribution system THM formation.

3. Intake Operations

The 2002 Treatability Study recommended pre-oxidation in the form of sodium permanganate as a feed at the intake. It is possible the addition of a pre-oxidant such as hydrogen peroxide or some type of permanganate could enhance the ozone process. Veolia evaluated permanganate demand during jar testing the week of February 16th, 2014 and further recommendations will be incorporated when results become available.

4. Seasonal Strategies

Past data indicates the Flint River is influenced by groundwater and in particular, dolomitic spring water. The result is hard water with high concentrations of magnesium and sulfate. Also, hardness and alkalinity are higher during the winter. Upon initiation of supply from the Flint River, the City made the decision to soften with just lime to focus on removal of carbonate hardness. One potential modification that could assist with TOC removal and thus decrease THMFP would be lime and soda ash softening. A temporary caustic soda feed system is recommended to be put in place in case the need for optimized softening arises.

5. Upstream Contamination Issues

Upstream contamination issues are extremely difficult to prevent and even if detected are difficult to locate. Evaluation of raw water data collected for MORs is the easiest

manner in which to detect upstream contamination issues because the data is already collected for treatment purposes. In fact, high total Coliform readings signaled a potential issue recently that the City identified and removed.

An upstream monitoring and warning system could be established to attempt to detect water quality issues or spill event type contamination early enough to adjust treatment procedures or cease intake prior to the contamination reaching the WTP. However, given the imminent conversion to the KWA supply, the period of full time use would likely be far too short to achieve payback on the capital expenditures.

B. TREATMENT PROCESS

1. Operational Recommendations

- Increase ferric chloride dosage: Previous testing in the 2002 Treatability Study, jar testing completed by LAN, and a review of 2014 ferric chloride dosages compared to THM levels leaving the WTP support that increasing the ferric chloride dosage would help reduce THM formation.
- Increased monitoring: Currently, the MDEQ does not require daily reporting of raw water TOC or finished water TTHM levels. However, daily tracking of such levels would allow the City to develop a correlation between the two, thus providing a predictive tool to help manage TTHM levels.
- Coagulation and flocculation polymer aids: The 2002 Treatability Study suggested the use of coagulation and flocculation polymer aids. These polymer aids were shown in the 2002 Treatability Study to increase TOC removal and thereby reduce THMFP. Further evaluation will be completed during jar testing.
- Discontinue softening bypass: The City was previously bypassing a portion of flow around the softening basins because hardness levels did not warrant softening of the full stream. However, this practice was discontinued because it was believed the bypass stream was contributing to chlorine demand and preliminary data has supported that belief. Chlorine demand dropped 0.5 – 1.0 mg/l following elimination of the bypass stream in early November 2014.
- Soften with lime and soda ash: Research has shown that enhanced softening with both lime and soda ash may provide additional TOC removal. The efficacy of this option will be evaluated during jar testing.
- Disinfection of filter beds: In case there has been microbial growth it is recommended the filters be 'shock' treated with chlorine and rinsed. A chlorine injection point was added upstream of the filters during the first segment of Phase II so future growth in the filters should not be an issue.
- Optimization of all existing treatment processes: Depending on bench scale testing conditions and results, slight modifications to all treatment processes might in order to replicate lower DPBFP.
- Discontinue or adjust softening anionic polymer feed: Some anionic polymers have been found to increase TOC. Veolia evaluated the anionic polymer currently being fed during their jar testing and depending on the results, when available, the softening anionic polymer feed should be adjusted accordingly.

2. Infrastructure Change Recommendations

- Fix and/or replace faulty ozone equipment: Since the ozone equipment was installed it has not been used extensively so the hope is that major components remain in good condition and the system can be easily modified to restore proper functionality. The City has scheduled the equipment manufacturer to field inspect the system on December 15, 2014.
- Replace filter media with GAC media: GAC media could help reduce THM levels by reducing both TOC and chlorine demand. For this consideration, the recommended approach would be to first complete small scale testing to verify efficacy. Upon positive results, the next step would be replacement of media in a fraction of the filters following by sampling to measure water quality. Those results would determine the need to replace media in additional filters.
- Change disinfectant to chloramine or chlorine dioxide: If other options prove to be ineffective, conversion to another disinfectant should be fully evaluated. Various characteristics of chloramination indicate an advantage over chlorine dioxide, but a full analysis would provide clarity as to which would be preferred.
- Install pre-oxidant chemical feed: Hydrogen peroxide or a form of permanganate as a pre-oxidant can enhance the activity of the ozone. Chemical feed could be installed at the intake structure or low service pump station, depending on the reaction time required. Use of a pre-oxidant at the intake might also provide the additional benefit of disinfection credit for ozonation with the MDEQ if an ozone residual can be obtained at the ozone process effluent as a result.
- Repair upstream sewer leak: a sewer leak upstream of the WTP intake was discovered and has already been repaired by the City.

C. DISTRIBUTION SYSTEM

Potential distribution issues related to water quality issues discussed in Section IV included old cast iron pipe, oversized infrastructure, and remote storage/pump station locations and operations that might be less than ideal. Recommendations to address those issues are offered in this section.

1. Manage Water Age

a) Storage Tanks

Considering the excess storage capacity discussed in Section IV, in the short term it is recommended that operational changes be implemented immediately to reduce the overall volume of water stored to decrease water age. Immediate operational recommendations include lowering high water levels of reservoirs other than the elevated tank, to reduce the total system wide usable storage volume to 30-36 MG.

In the long term, LAN recommends development of the most ideal options for water model evaluation. Excess storage volume and tank locations within the water system afford Flint numerous options to reduce the amount of storage volume utilized. As a starting point, two recommendations are presented below.

Option 1

- Take West Side reservoir and pump station out of service
- Cut storage volume used in half at Cedar Street reservoir
- Reduce the utilized storage volume of the WTP clearwell from 3 MG to 2 MG
- Adjusted system wide storage volume would be 34 MG

Option 2

- Take Cedar Street reservoir and pump station out of service
- Reduce the utilized storage volume of the WTP clearwell from 3 MG to 2 MG
- Adjusted system wide storage volume would be 36 MG

b) Residence Time in Pipes

Completely redesigning and replacing the water system to match today's demands is not feasible financially and would be a waste of infrastructure with remaining useful life. Going forward, it is recommended that any future main replacement projects be evaluated for possible downsizing. When the water model is fully updated, it will provide a valuable tool in determining which mains can be downsized and to what extent. Replacement of broken valves and valve exercising are also recommended, which are programs that have already been implemented into Flint's regular operations.

Operationally, hydrant flushing is recommended as needed to minimize water age in low flow areas. Again, the updated water model should be used to locate high water age areas and optimal flushing points.

2. Reduce Disinfectant Demand

Recommendations to reduce disinfectant demand are similar to those described above to reduce water age. Replacement of old cast iron pipes would lead to a reduction of disinfectant demand on the distribution side, but realistically can only be accomplished over a prolonged period of time. In the meantime, hydrant flushing is the most viable means of reducing disinfectant demand in piping. From a storage standpoint, all reservoirs and tanks should be regularly inspected and maintained to prevent entrance of any outside contamination that would contribute to disinfectant demand.

3. Water Modeling of Recommendations [yet to be completed]

Determine best flushing locations to reduce water age
Evaluate changes in storage tank operations to reduce water age
Valves to close/add to improve pressure zones, reduce recirculation
Optimization of pump station use – smaller pumps? Shut down?
Evaluate booster disinfection

D. BOOSTER DISINFECTION

Decreasing chlorine feed at the WTP and adding booster disinfection in the distribution system is an alternative intended to reduce the reaction time at higher concentrations of chlorine to reduce DPB formation. Extensive looping and branching within the existing system complicate how to best implement and utilize booster disinfection. Water system modeling is recommended to gage the effectiveness of existing feed point locations and dosages. Further discussion and details will be provided when the distribution evaluation results are available.

E. CATEGORIZATION OF ACTIONS

Considering that the Flint River is being used as the water source only until the KWA supply is available (expected late 2016), options to address high THM formation that require new construction or extensive time to implement are not preferred. On the other hand, the City understands THM sample results to date dictate that some action is necessary. Two categories have been developed to assist the City in prioritizing actions to take. Stage 1 consists of actions that can be completed relatively quickly without major construction and Stage 2 actions are either long term actions or solutions requiring major construction. Stage 1 actions are to be completed first followed by evaluation of the results prior to consideration of Stage 2 actions. Grouping of actions are shown in the table below.

TABLE 11 – ACTION PLAN

	Action	Purpose
Stage 1	Hire water consultant to complete 'water audit'	Third party review of actions and operations to make sure no options are being missed
	Increased water quality monitoring – obtain THM and TOC analyzers	Provide information needed to adjust WTP operations to match changing raw water quality
	Troubleshoot ozone feed system	Reduce chlorine feed and increase TOC removal
	Bench scale jar testing	Optimize treatment process and evaluate possible modifications
	Discontinue softening bypass	Reduce chlorine demand
	Disinfect filters	Reduce chlorine demand
	Increased water main flushing	Reduce water age / stagnant water
	Water system modeling evaluation	Determine areas with high water age and reasons
	Implement coag. & floc. polymer aids, if appropriate	Increase TOC removal
	Modify booster disinfection feeds, if appropriate	Decrease water age
Stage 2	Repair ozone system	Reduce chlorine feed and increase TOC removal
	Continue increased water main flushing	Reduce water age / stagnant water
	Convert to lime and soda ash softening	Increase TOC removal
	Continue valve replacements based on water model	Reduce water age / stagnant water
	Replace filter media with GAC	Reduce TOC and chlorine demand
	Change disinfectant to chlorine dioxide	Reduce THMFP
	Install pre-oxidant feed at intake	Optimize ozone disinfection, reduce chlorine
	Place priority on replacing cast iron water mains	Reduce chlorine demand

Samples were taken the week of February 16th for the 4th round of quarterly testing. The City has implemented many of the Stage 1 actions and THM test results have significantly improved (decreased) each time samples have been taken since August 2014. In addition to the regular compliance monitoring, the City performed a round of sampling on January 27, 2015. All sampling results are shown on Chart 1.

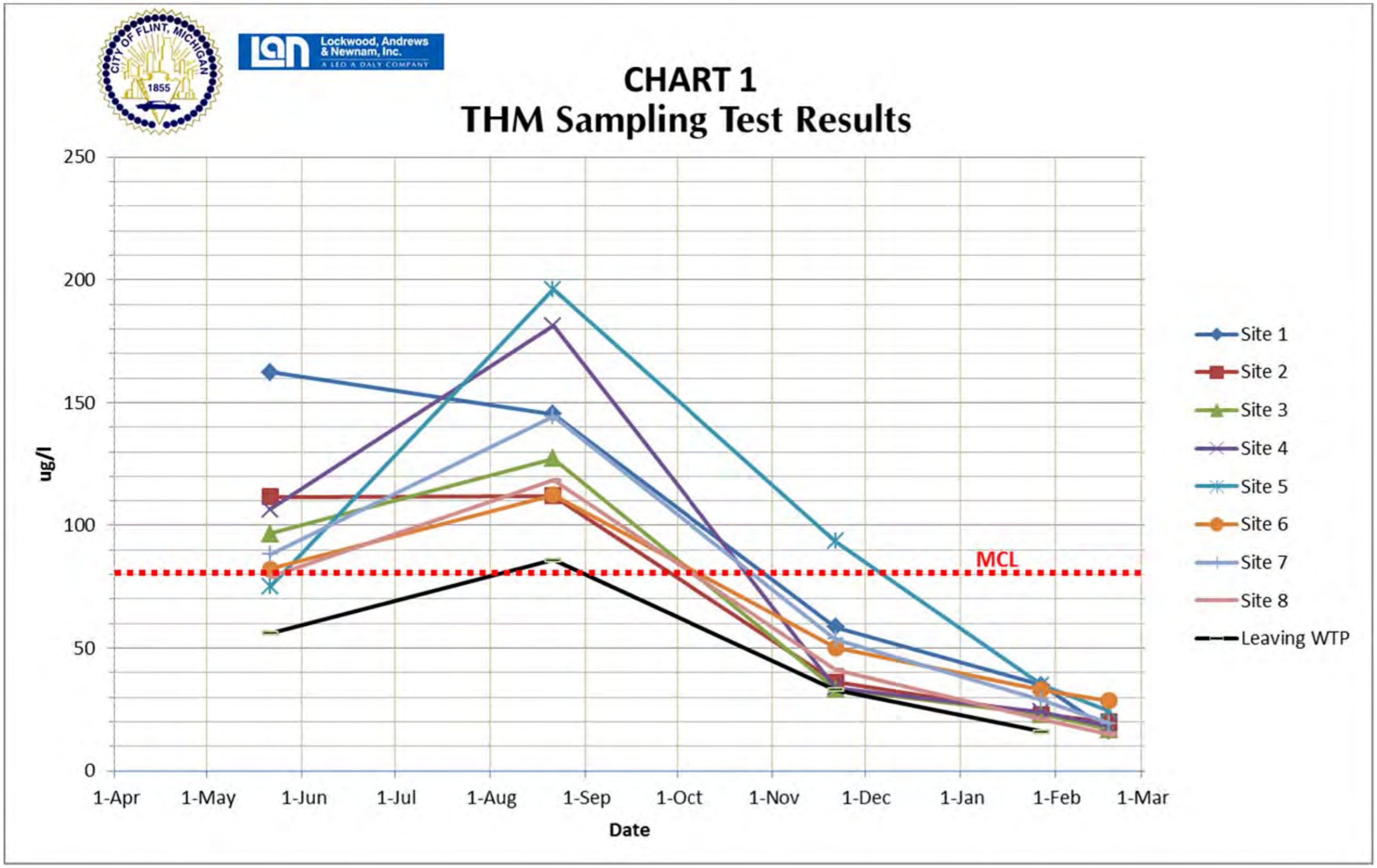
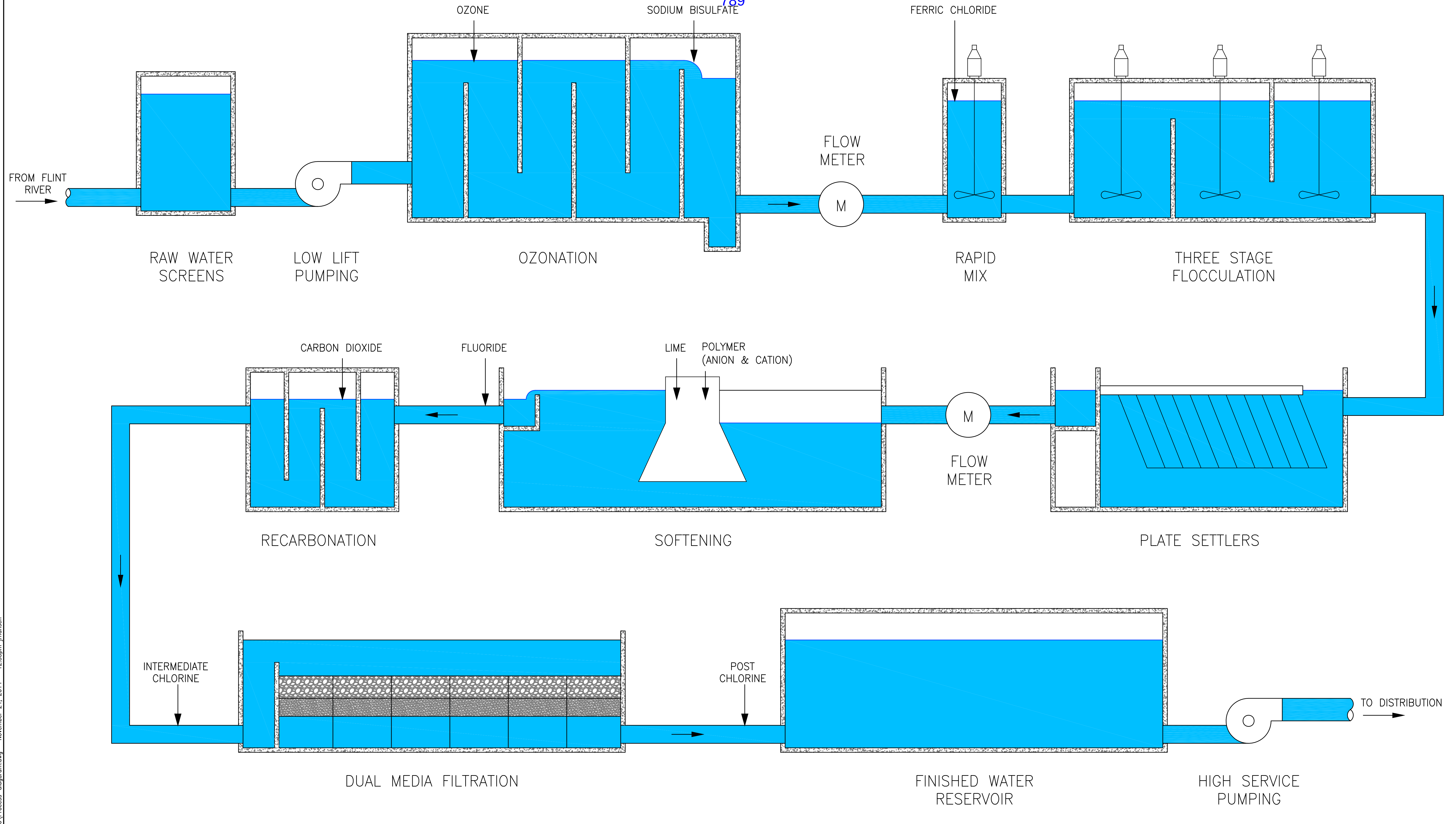


CHART 1
THM Sampling Test Results



Genesee County

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
PLANNING ENGINEERING PROGRAM MANAGEMENT
1311 S. Linden Road, Suite B
Tel 810-820-2682 Fax 810-820-2703
www.lan-inc.com

CITY OF FLINT
WATER TREATMENT PLANT

REVISIONS
NO. DESCRIPTION DATE

FILE LOG
ACTIVITY BY
Manager JWG
Design
Drawn JRH
Check JRH

WATER TREATMENT PLANT
PROCESS DIAGRAM

Project No. 130-10701-001
Date Nov. 21, 2014

Sheet
FIG 1

C:\projectwise\jrhansen\d0263766\Process-diagram.dwg November 24, 2014 - 12:55pm jrhansen

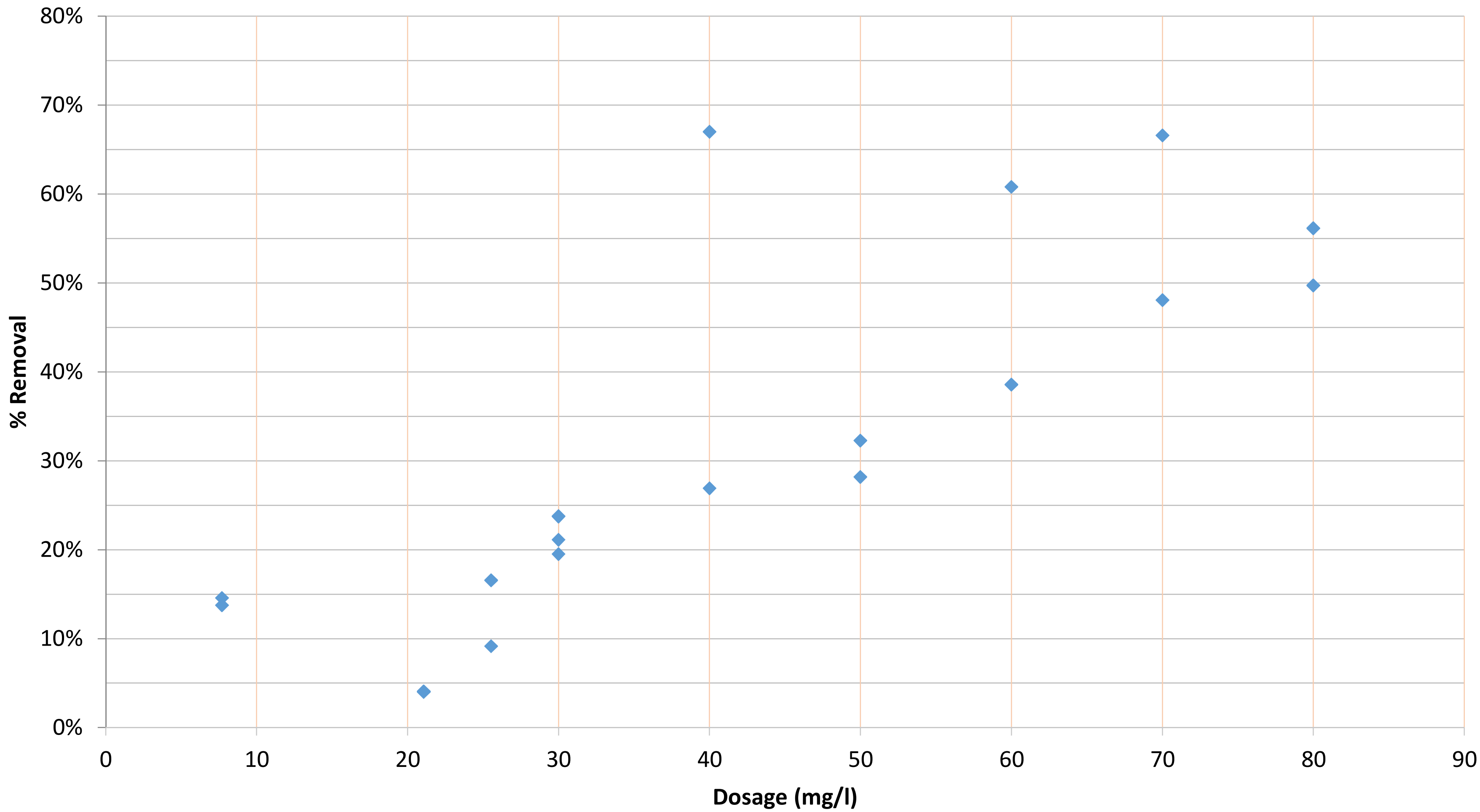
APPENDIX A
JAR TEST DATA

CITY OF FLINT, MICHIGAN 1855

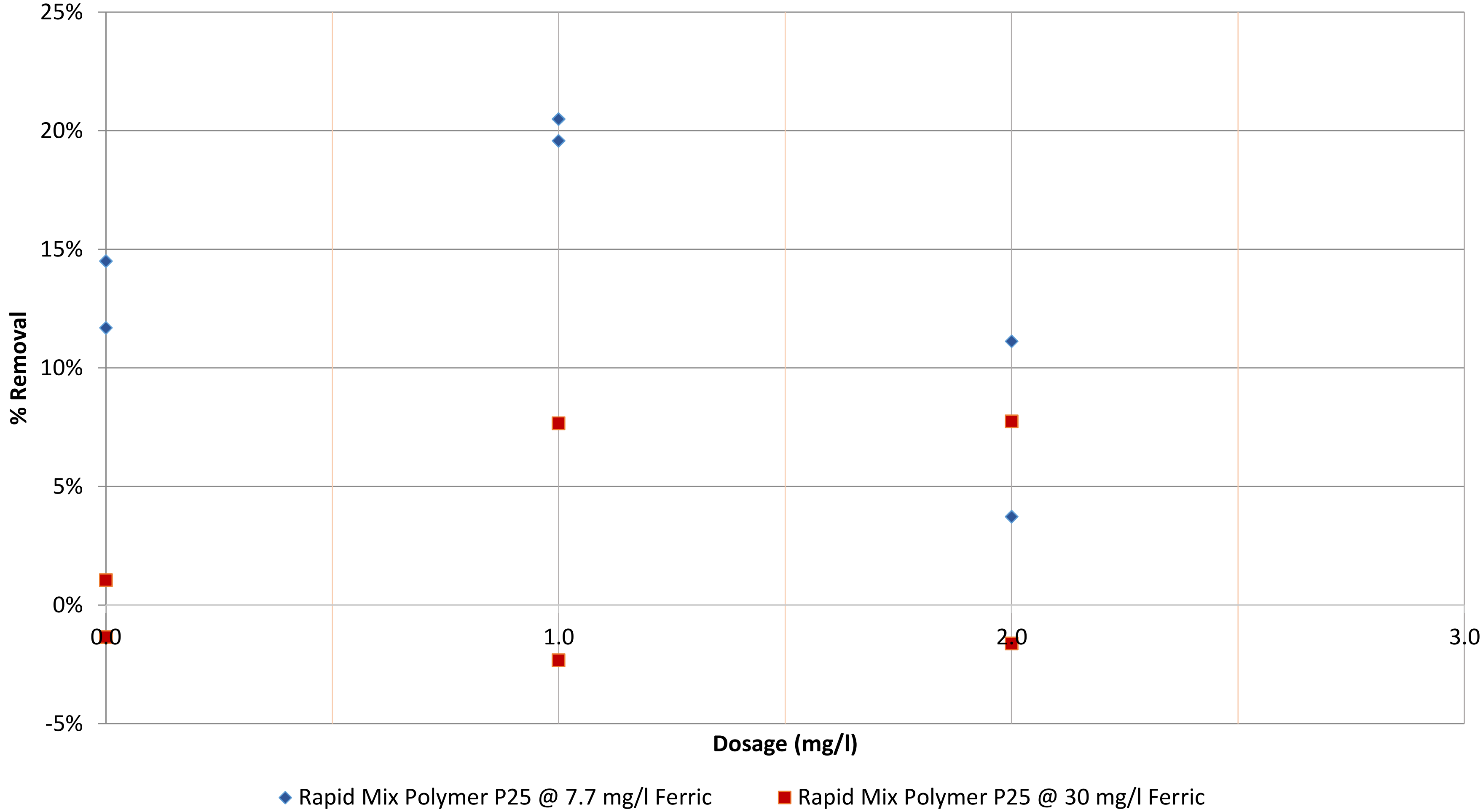
Lockwood, Andrews & Newnam, Inc. A LEO A DALY COMPANY

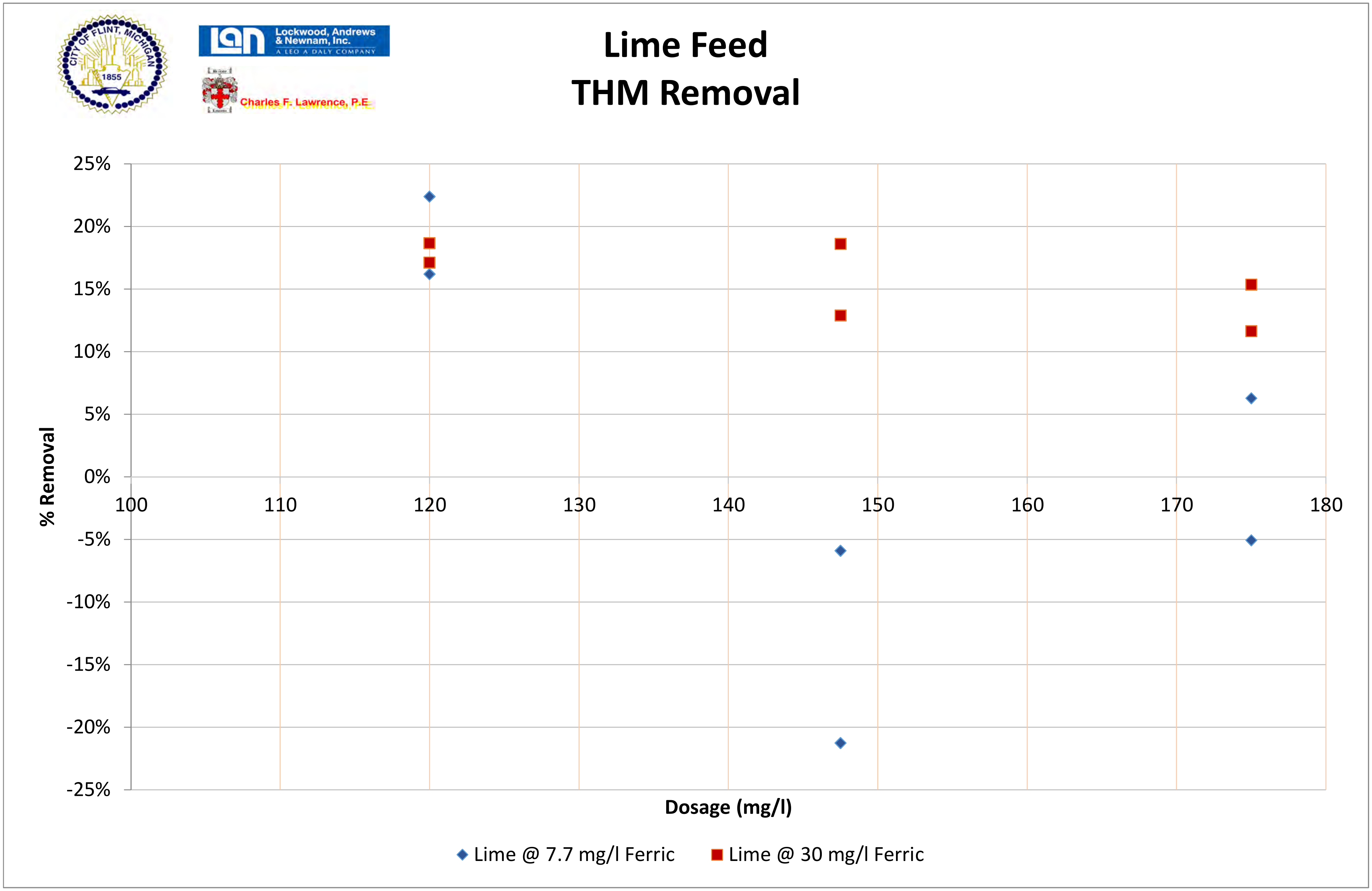
Charles F. Lawrence, P.E.

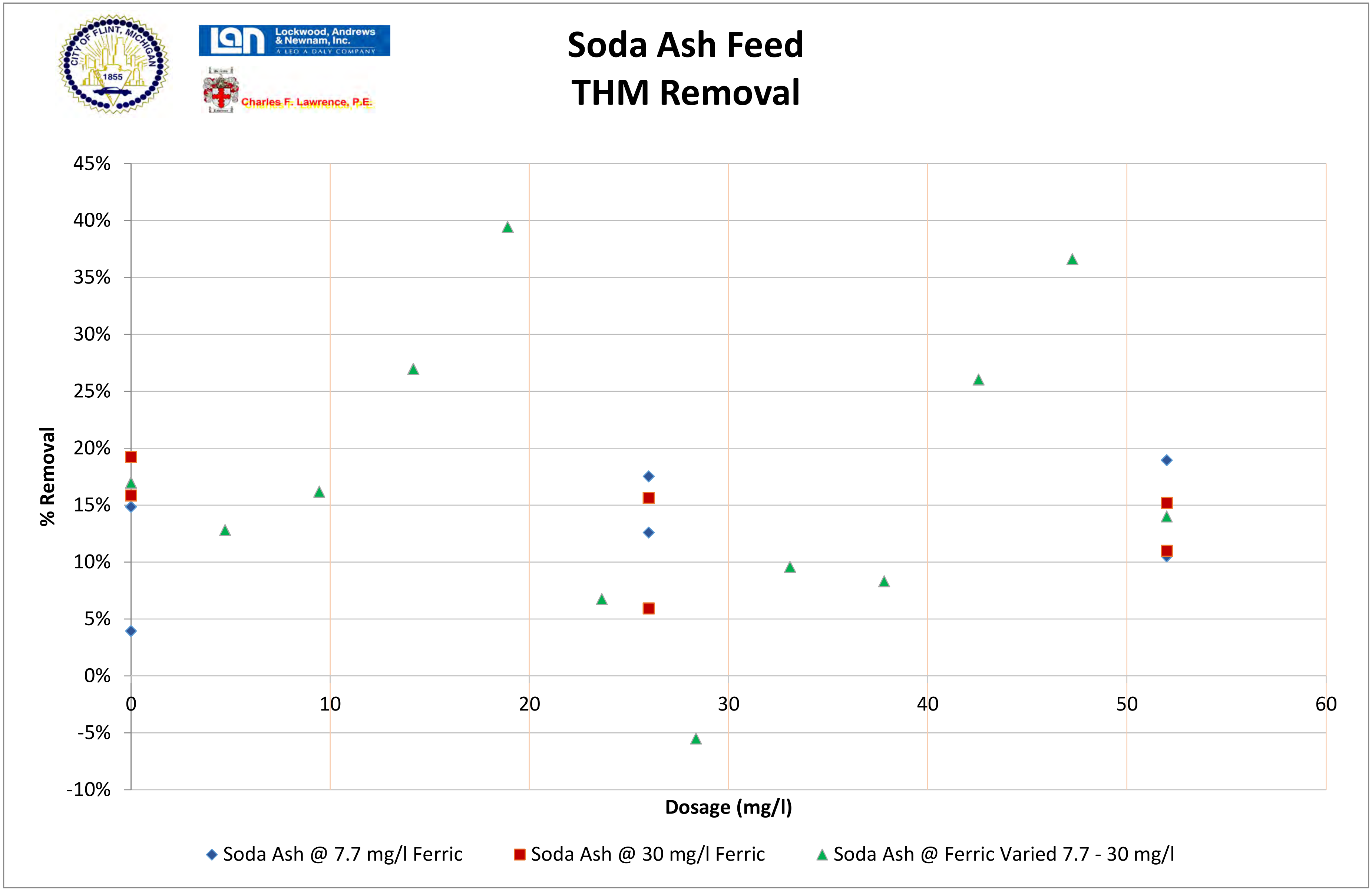
Ferric Chloride Feed THM Removal



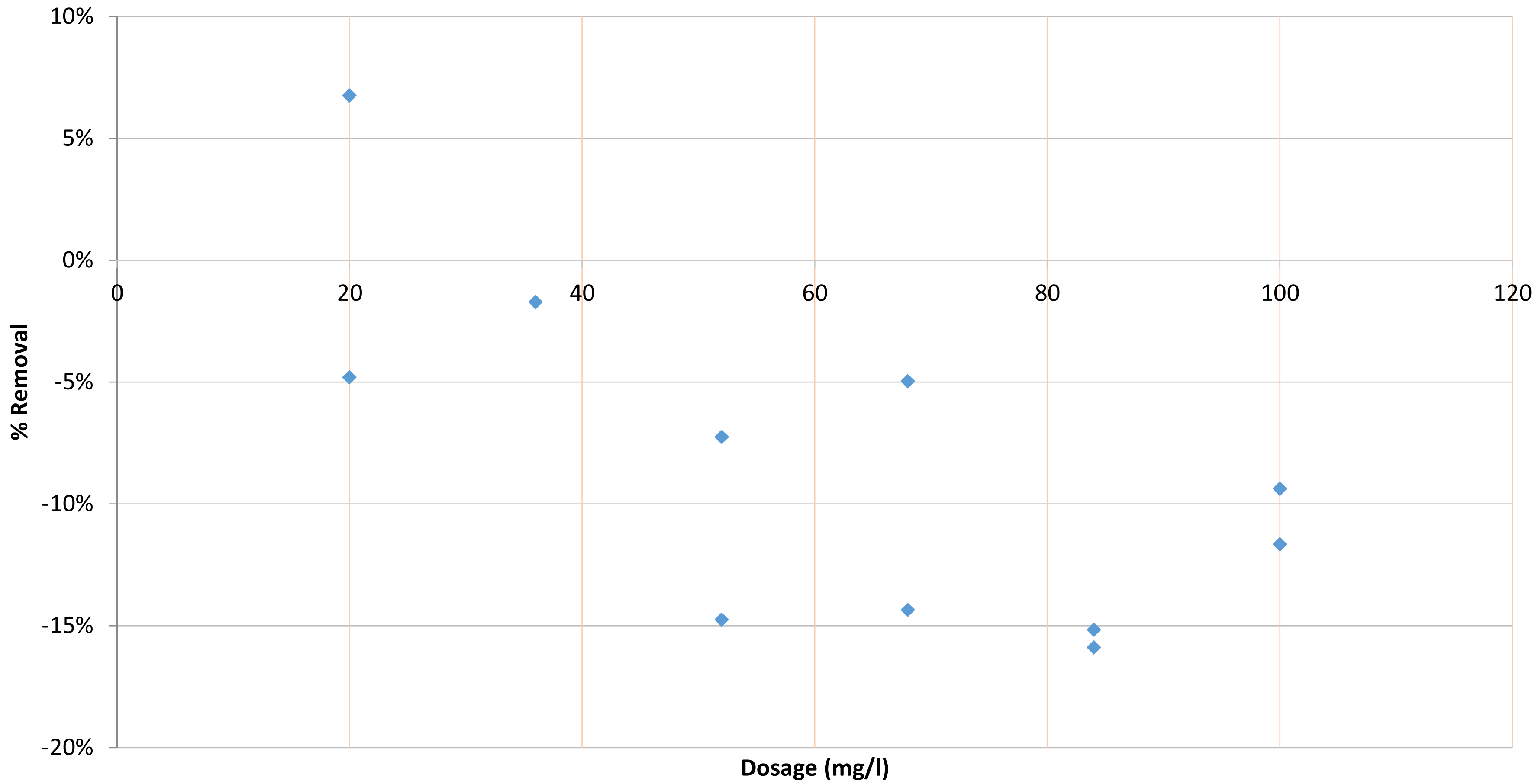
Coag/Floc Polymer Aid THM Removal




Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
Charles F. Lawrence, P.E.
Lime Feed
THM Removal
25%
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
-25%
% Removal
100
110
120
130
140
150
160
170
180
Dosage (mg/l)
Lime @ 7.7 mg/l Ferric
Lime @ 30 mg/l Ferric

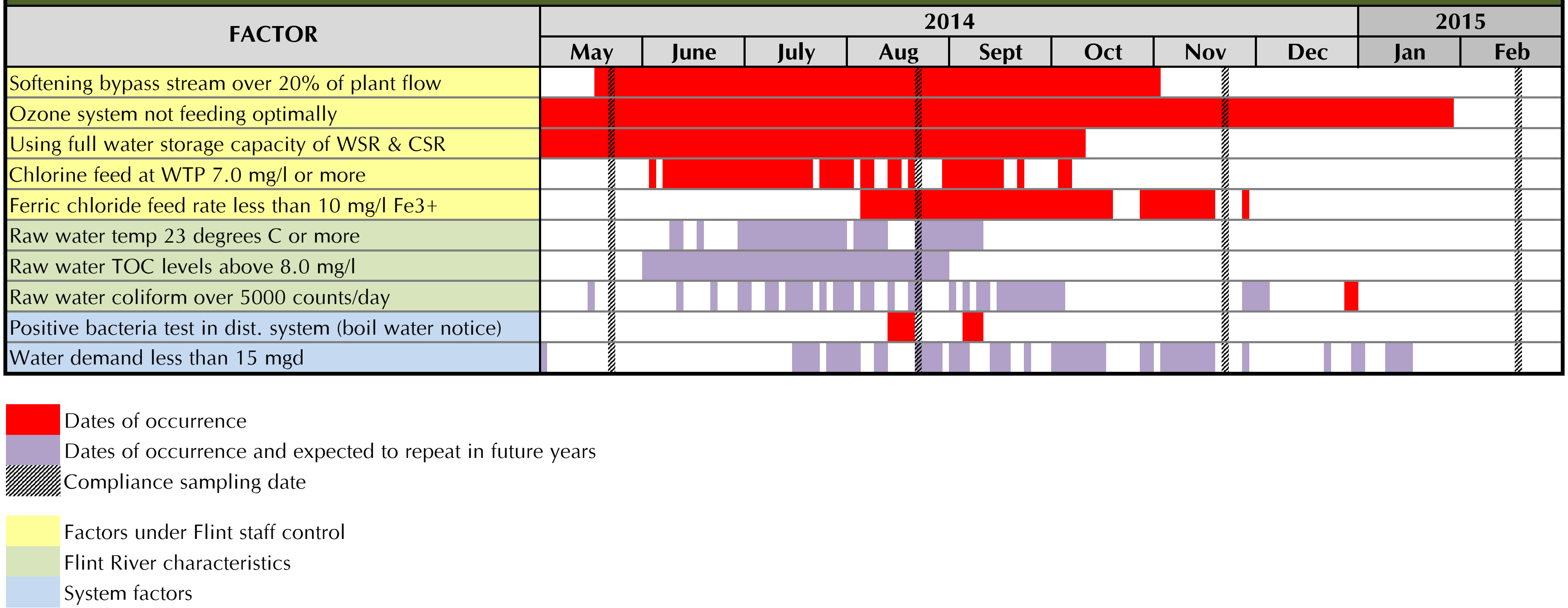

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
Charles F. Lawrence, P.E.
Soda Ash Feed
THM Removal
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
-5%
-10%
% Removal
0
10
20
30
40
50
60
Dosage (mg/l)
Soda Ash @ 7.7 mg/l Ferric
Soda Ash @ 30 mg/l Ferric
Soda Ash @ Ferric Varied 7.7 - 30 mg/l

PAC Feed
THM Removal



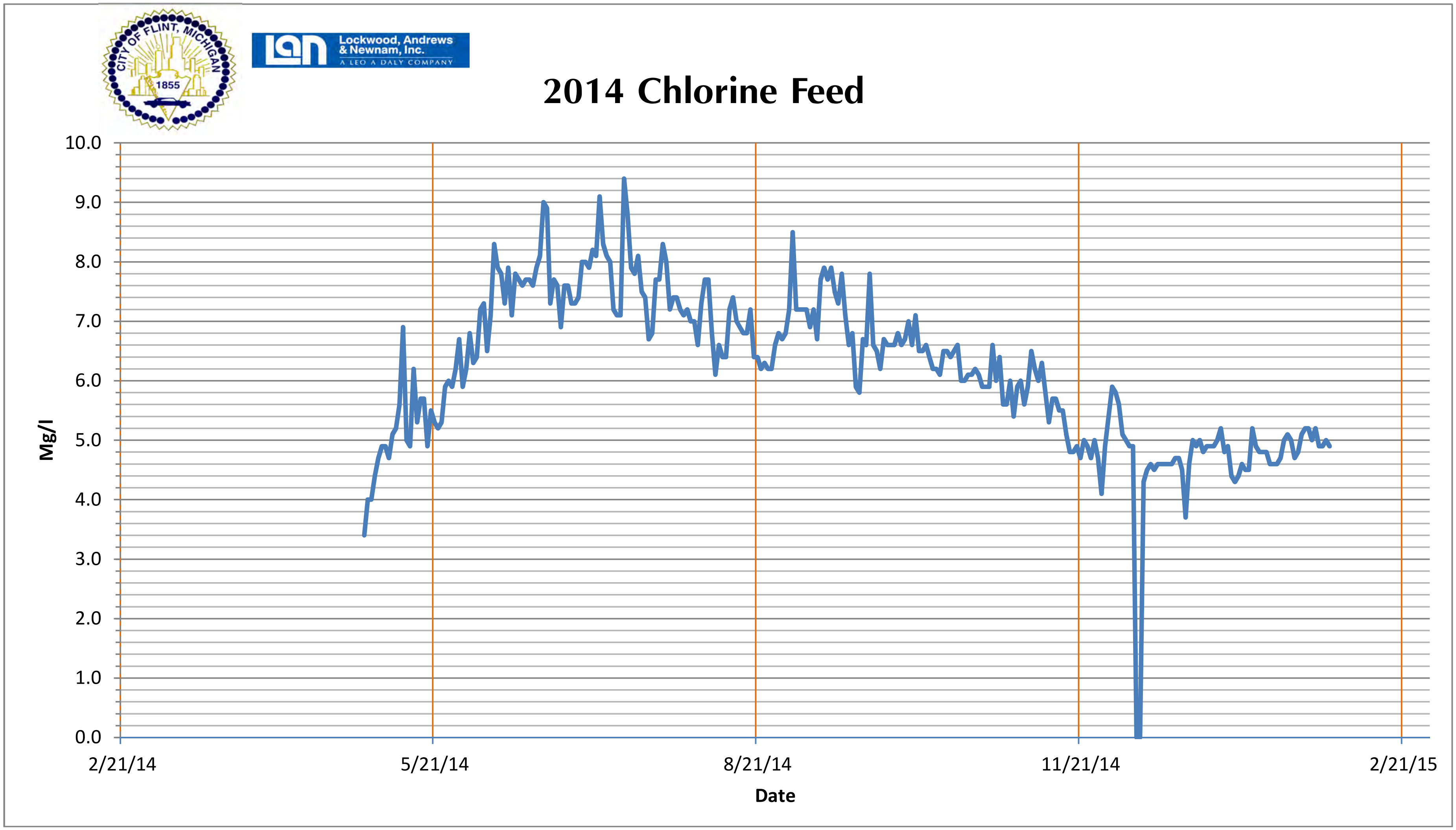
APPENDIX B
WTP DATA

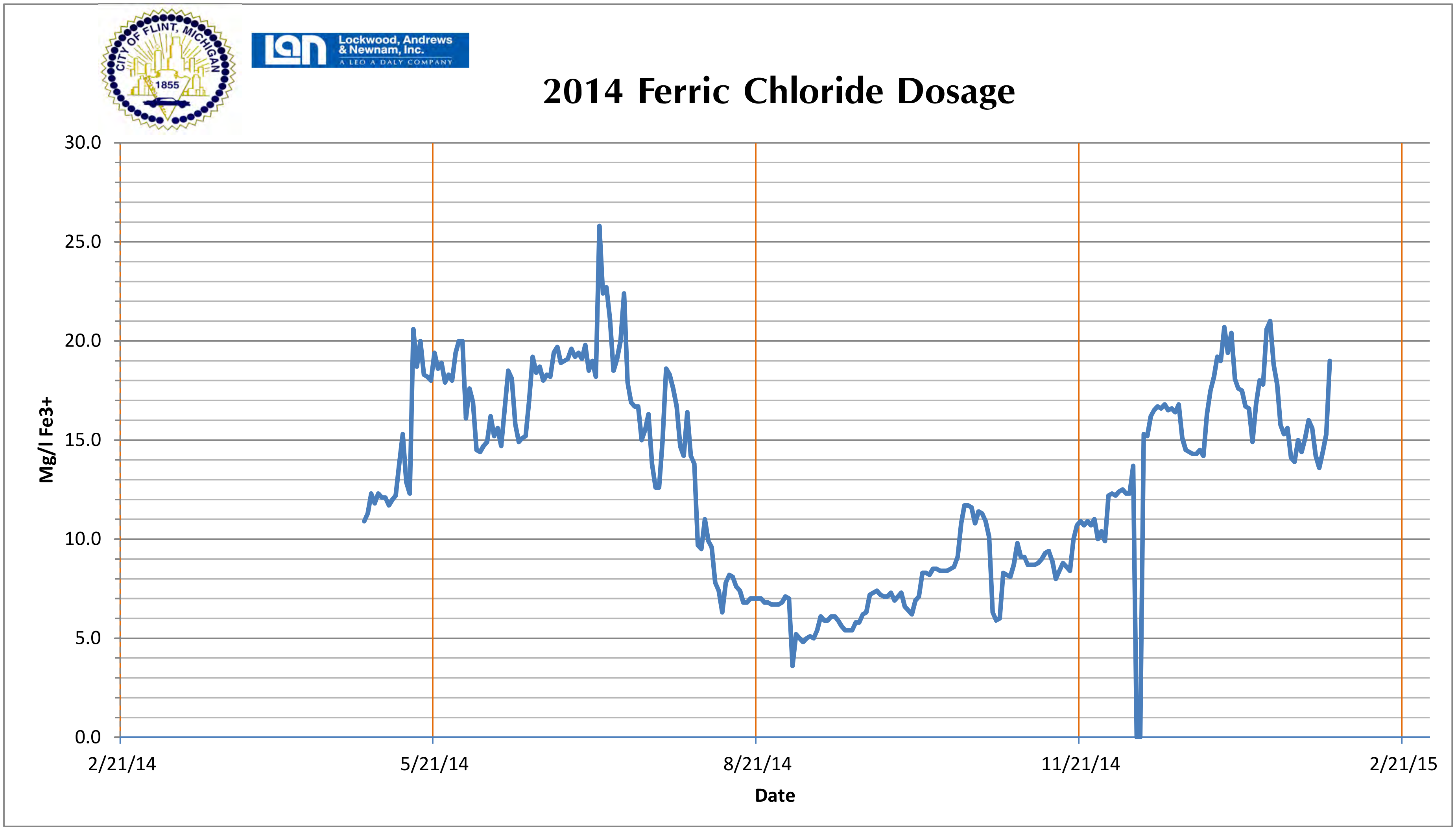
TABLE 1 - SUMMARY OF NEGATIVE INFLUENCES ON THM COMPLIANCE SAMPLING



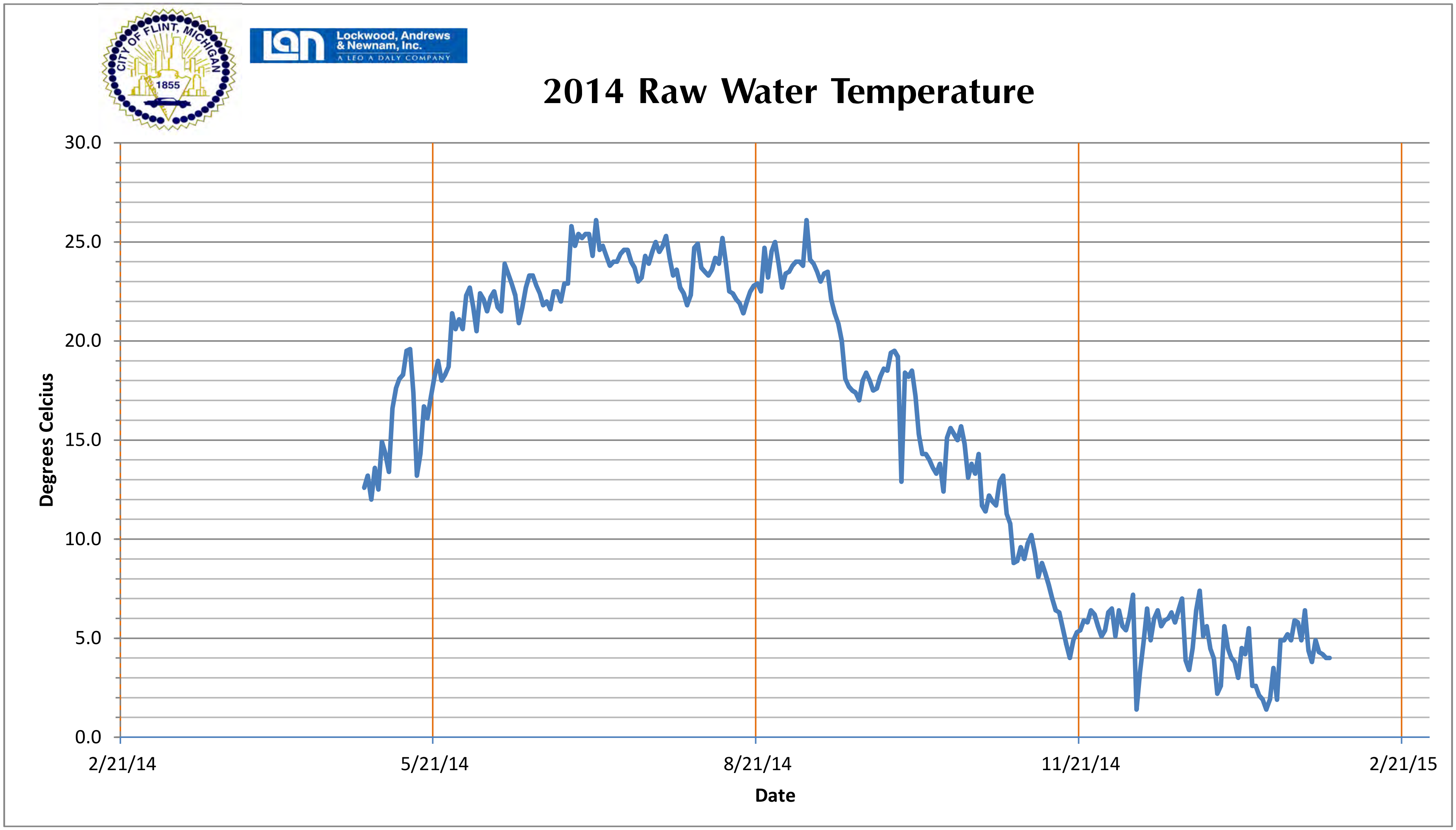
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

PLANNING
ENGINEERING
PROGRAM MANAGEMENT

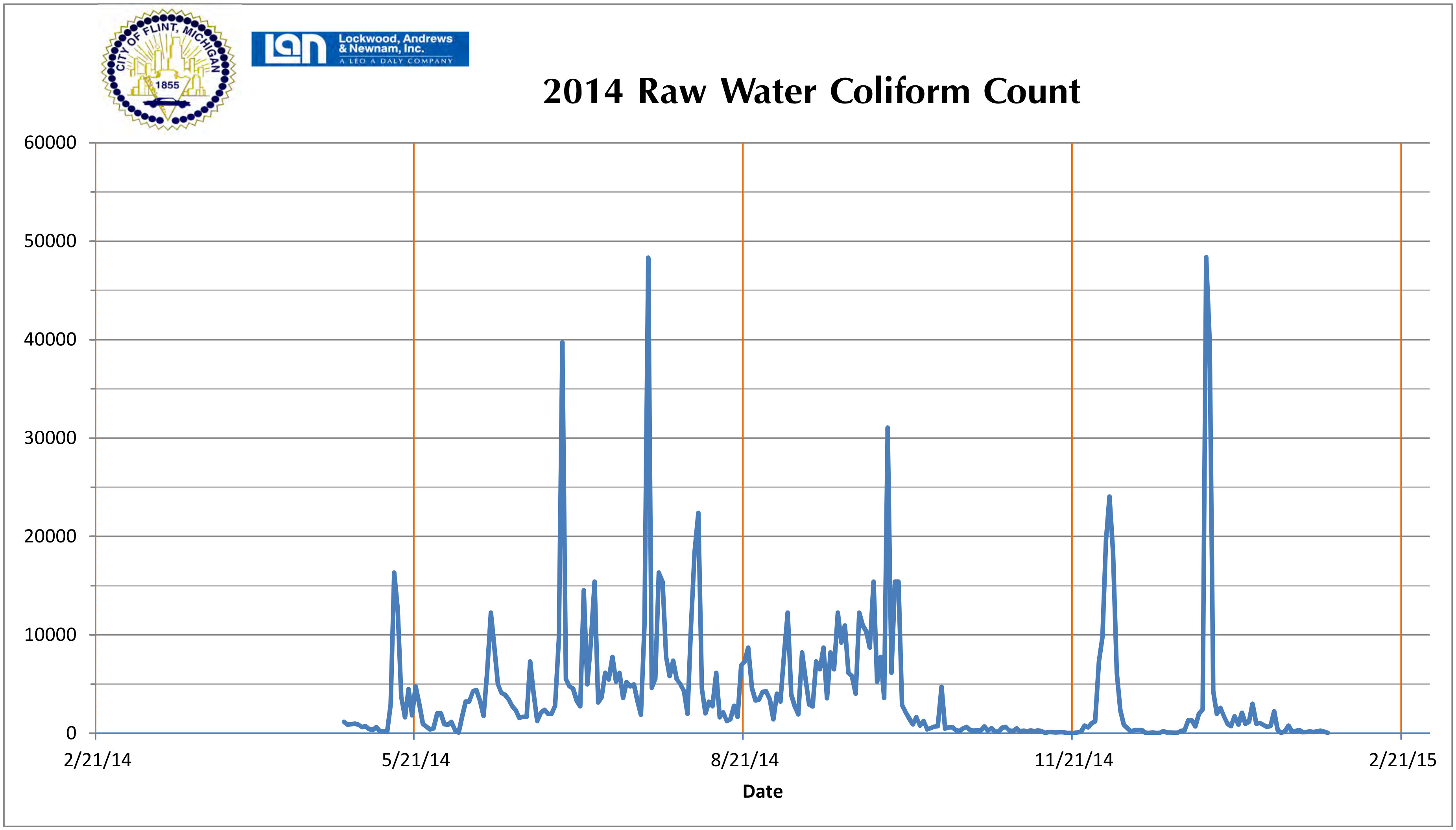

CITY OF FLINT, MICHIGAN
1855
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
2014 Chlorine Feed
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Mg/l
2/21/14
5/21/14
8/21/14
11/21/14
2/21/15
Date



Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
2014 Ferric Chloride Dosage
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Mg/l Fe3+
2/21/14
5/21/14
8/21/14
11/21/14
2/21/15
Date



CITY OF FLINT, MICHIGAN
1855
LAN Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
2014 Raw Water Temperature
Degrees Celcius
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2/21/14
5/21/14
8/21/14
11/21/14
2/21/15
Date


CITY OF FLINT, MICHIGAN
1855
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
2014 Raw Water Coliform Count
60000
50000
40000
30000
20000
10000
0
2/21/14
5/21/14
8/21/14
11/21/14
2/21/15
Date

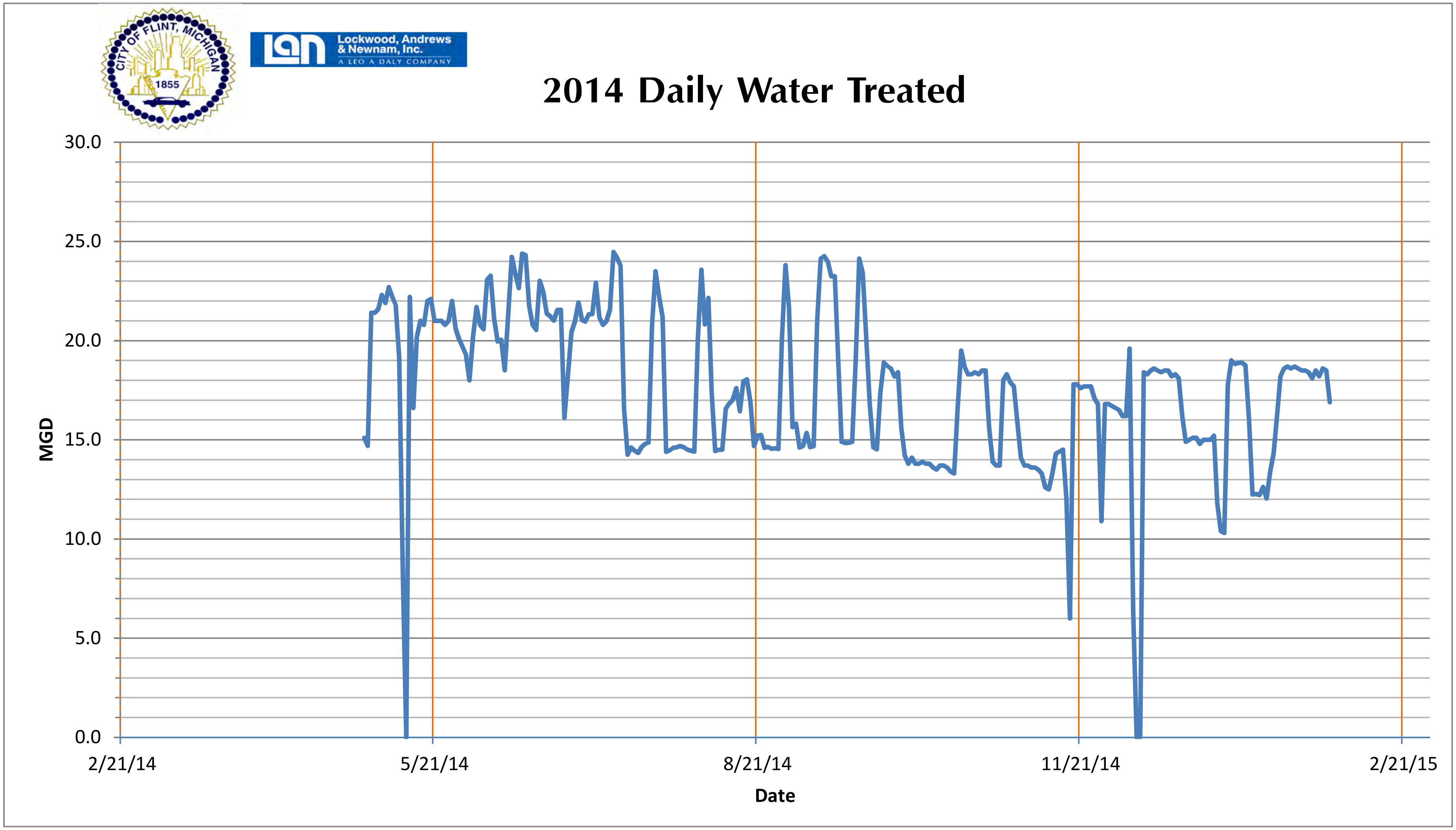

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
2014 Daily Water Treated
MGD
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2/21/14
5/21/14
8/21/14
11/21/14
2/21/15
Date

EXHIBIT HH

VEOLIA

FLINT, MICHIGAN

Water Quality Report

MARCH 12, 2015

VEOLIA

Water Quality Report
March 12, 2015

FROM

Veolia North America

TO

Emergency Manager Gerald Ambrose

Executive Summary

The City of Flint changed water sources, transitioning from Detroit's system to the Flint River. This change created water treatment challenges that have resulted in water quality violations. Aging cast-iron pipe has compounded the situation, leading to aesthetic issues including taste, odor and discoloration. Public interest and scrutiny of the drinking water system intensified following the distribution of required public notices of violation.

The City of Flint has made a number of good decisions regarding treatment changes that have improved water quality. However, this is a very complex water quality issue and the City is seeking additional advice on what to do to ensure healthful drinking water for the community.

Veolia appreciates the City's decision to seek independent third parties to review current treatment processes, maintenance procedures and actions taken to date, and provide ideas for improvement. We are pleased to present this final report to the City of Flint following our experts' 160-hour assessment of the water treatment plant, distribution system, customer service and communications programs, and capital plans and annual budget.

This report provides recommendations and a roadmap for improvement, though our engagement was limited in scope. Our assessment included reviewing actions taken by the City to date, validating the City's plans going forward, and making recommendations for ideas not being considered.

Although a review of water quality records for the time period under our study indicates compliance with State and Federal water quality regulations, Veolia, as an operator and manager of comparable utilities, recommends a variety of actions to address improvements in water quality and related aesthetics including: operational changes and improvements; changes in water treatment processes, procedures and chemical dosing; adjustments in how current technologies are being used; increased maintenance and capital program activities; increased training; and, an enhanced customer communications program.

We are also providing a recommended schedule and estimated costs for implementing changes. It is our desire to help Flint residents and public officials better understand the current situation so that informed decisions can be made to ensure safe drinking water for the city's customers.

Review of Actions Taken to Date

To address water quality issues, the city has made operational changes, sought help from the State, hired engineering firm Lockwood, Andrews & Newnam, Inc. (LAN) to provide additional advice, and hired Veolia for an assessment from a utility operator's perspective. The City has also reached out to different specialty vendors (chemical suppliers, filter companies and tank aeration companies) for information about products to help with the TTHM issues. These are logical steps to take.

Flint is not alone in dealing with TTHM problems, as many utilities across the country are facing this challenge. The City appears to be following standard steps that many of those communities are taking to successfully correct the problem.

Although the primary focus of this review was based on solving the TTHM problem, the public has also expressed its frustration over discolored and hard water. Those aesthetic issues have understandably increased the level of concern about the safety of the water.

The review of the water quality records during the time of Veolia's study shows the water to be in compliance with State and Federal regulations, and, based on those standards, the water is considered to meet drinking water requirements.

The City has been proactive in its efforts to reach out to the medical community, to set up a phone number and email address to receive complaints, to post State Water Quality reports, to provide the list of EPA required water tests, and offer to test the water at customers' homes.

From our review, these numerous efforts demonstrate how the city is trying to be transparent and responsive beyond what many other communities might do in similar circumstances.

State Report

The Michigan Department of Environmental Quality (MDEQ) has requested specific actions be taken related to the total trihalomethane (TTHM) issues. The February 2015 report from LAN (*Operational Evaluation Report TTHM Formation Concern*) indicated apparent reasons for the elevated levels of TTHM in the distribution system. These generally relate to high Total Organic Carbon (TOC) in the water source, improperly operating equipment both in the plant and the distribution system, less-than-optimal plant TOC removal and old cast-iron pipe in the distribution system. **Our assessment confirms that these reasons are likely given our on-site laboratory testing and analysis, as well as our first-hand observations.**

Due to time constraints, LAN's report to the State was submitted prior to Veolia's final analysis and recommendations, and contained a number of key initial and contingent steps the City should consider, including:

Initial Actions

- Hire a Third Party Water Quality Expert to Complete Independent Audit
- Obtain a THM Analyzer
- Carry Out Jar Testing
- Water Plant Optimization Softening
- Water Plant Optimization Disinfection of Filter Beds (Pre-Chlorination)
- Water Plant Optimization Polymer Aid to Coagulation and Flocculation
- Increase Water Main Flushing
- Water Modeling Cedar Street Pump Recirculation
- Water Modeling West Side Pump Recirculation
- Broken Valve Locations
- Increase Flushing

Contingent Actions

- Fix Ozone System
- Start Feeding Coagulant and Flocculation Polymer
- Convert to Lime and Soda Ash Softening
- Change Disinfection to Chloramine or Chlorine Dioxide Temporarily
- Install Pre-Oxidant at Intake
- Replace Filter Media Implement Advanced Treatment
- Increase Main Flushing
- Continue Valve Replacement
- Emphasize Cast Iron Pipe Replacement

Veolia's Recommendations

While many of Veolia's recommendations match the initial assessment provided by LAN, our approach, as an operator and manager of comparable utilities, considers a more comprehensive solution. These improvements include operational changes, differences in water treatment regimes and chemical dosing, increased maintenance, and increased training.

- **Addition of Permanganate** – The addition of a permanganate chemical will help reduce ozone demand as well as chlorine demand. The reduction of ozone is needed to help eliminate the possibility of violating the bromate limit. The addition of the chemical will require state approval, submission of design documents for approval, procurement of the equipment and installation. The State has indicated they will work with the City on expediting review and approval of any requested changes. The required dosage of permanganate is estimated to range from 0.5 mg/L to 1.2 mg/L with a corresponding price of $160,000 to $320,000 per year. (Please note – The water in the river is dynamic which means it will change with weather, seasons and other factors. The estimates provided are based on bench testing at a given time and as such require the operators to test water and to verify chemical dosages on a frequent basis.)
- **Reduction of Ozone Feed** – Treating water is a delicate balance - increasing ozone to fix the TTHM problem can raise bromate levels to a point of violation. The introduction of permanganate is being recommended to reduce the demand for ozone so that feed rates will not exceed 5 mg/L. The current ozone dosing has been as high as 8 mg/L and, as such, if allowed to continue, will increase the risk of violating the bromate levels.
- **Increase of Ferric Chloride** – Four coagulants were tested by Veolia -ferric chloride, ferric sulfate, polyaluminum chloride (PACl) and aluminum chlorohydrate (ACH). Ferric chloride and ACH were found to be the best choice of product for effectiveness in removing TOC, a precursor to TTHM formation. Current ferric chloride dosages are too low and dosages of 100 mg/L or more are recommended. Again, please note, that the amount of chemical needed changes with the nature of the river and as such, water must be tested multiple times a day with corresponding changes in chemical dosages. This increase to 100 mg/L is twice what is currently being fed and much higher than what had previously been fed last year. The increase in chemical costs could be up to $1,000,000 per year. This change in dosage (using ferric chloride) can be made immediately without state permit review.
- **Reduction of Lime** – Lime is currently being overfed. A higher dosage of lime does not necessarily mean better treatment. A review of different dosages with jar testing indicates that the current dosage of 280 mg/L can be reduced to 230 mg/L. This represents a potential range of savings of up to $270,000 per year. This change can be made immediately. It should be noted that the current softening equipment is in poor condition, which does complicate the treatment process with a poor balance of flow between the two basins, weirs that are not level causing bypassing with the softener basins, and simply old mechanical equipment that periodically breaks down. This equipment is not going to be needed when a change to lake water occurs. Addition of soda ash to help further reduce hardness in cold weather might require dosages up to 40 mg/L with an annual chemical cost up to $320,000. There have also been some questions or complaints from the public regarding hard water. The water entering the plant is currently 360 mg/L and the plant is reducing that level of hardness to about 210 mg/L. Optimization of the dosage can reduce the hardness

further to about 180 mg/L. This reduction however has been sporadic as equipment breakdowns and high flows have caused problems keeping the softening process on-line. As we have noted before, the dosage needs to be adjusted daily or more often based on process control monitoring. The raw water hardness in the summer is much less than in the winter. For illustration purposes, the difference could be 360 mg/L in raw water in winter compared with 220 mg/Lin the summer.

- **Eliminate Pre-Chlorination on the Filters** – The reduction of pre-chlorination on the filters during the summer months can help reduce TTHM formation. This action has to be considered carefully with procedures documented and reviewed for engineering principles. As such, it will take time for the design engineer to determine what could be done to assure the proper chlorine contact time and document that other safety protocols in water are met. This requires state approval. Any submission should be considered along with a possible change in filter media. If Granulated Activated Carbon (GAC) is installed then the pre-chlorination would be stopped or drastically reduced because of the chlorine impact on the GAC filter media. Veolia's initial investigation into changes in chlorine feed point indicate that the recommended action can be accomplished while maintaining the required regulatory contact time for disinfection.
- **Change Filters to Granulated Activated Carbon (GAC)** – The object of the other changes being made is to reduce the TOC before chlorine is added into the process. The plant by design is limited on the amount of TOC removal possible. A maximum removal of only 60% is likely if the plant is properly optimized. The change of filter media to GAC would provide the best reduction possible and provide better than 90% removal dramatically reducing the potential for TTHM formation and thus ensuring compliance with that parameter for the water system. The change in filter media; however, is complicated requiring approval by the state, design of the changes, procurement of the media and a contractor to install it. That will take time and is likely in a range of $1.5 million (more or less) in cost. The use of GAC also requires more testing and monitoring of the media and the TOC than with the current media. GAC will accumulate TOC and begin to become in effective after a period of time. Depending upon the level of TOC reaching the filters this could be as short as 3 months and as long as 9 months. The amount of TOC is dependent upon the river water quality and operation of the other plant processes. Once the ability of the filters to remove TOC is diminished, the GAC media has to be replaced if river water continues as a source. The change to lake water will not require TOC removal and the media could continue to be used as filter media for that new water source.
- **Corrosion Control** – The primary focus of this study was to assure compliance with the TTHM limits. That is not the only problem facing the city and its customers though. Many people are frustrated and naturally concerned by the discoloration of the water with what primarily appears to be iron from the old unlined cast iron pipes. The water system could add a polyphosphate to the water as a way to minimize the amount of discolored water. Polyphosphate addition will not make discolored water issues go away. The system has been experiencing a tremendous number of water line breaks the last two winters. Just last week there were more than 14 in one day. Any break, work on broken valves or hydrant flushing will change the flow of water and potentially cause temporary discoloration.
- **Eliminate a Storage Tank** - The water system has more storage than it requires, due to excess capacity in the water lines in combination with the storage tanks. The City has already employed LAN to update the hydraulic model. The hydraulic model should be used to help determine if water levels can be lowered further and even to remove some storage tanks from service. That decision may need to be made

seasonally. For example demand during water main breaks last week required extensive amounts of water. The excess storage is more a problem with TTHM formation for the system in summer than winter.

- **Prioritize Valve Replacement** - The hydraulic model shows long water age in portions of the system that appear to be contributing to the TTHM problems. LAN has updated the model to include the location of broken valves and that added information is being used to identify other system problems. The City has a contract for valve turning and repair work that should be focused on known broken valves, particularly in sections of the distribution system with old water age. This activity however must wait until warmer weather in fear of causing problems in the water system with lines freezing.
- **Target and Increase Flushing** – Flushing the fire hydrants can be useful in cleaning out lines to minimize discolored water complaints and also helping reduce the age of water. This DOES NOT mean just opening hydrants. The hydraulic model needs to be used to determine which hydrants should be opened and for how long to ensure the lines are properly cleaned. For example, this might require 15 minutes or even several hours of flushing depending on location. The flushing of hydrants also needs to include records of hydrant condition, color of water initially and after periodic increments plus chlorine residual testing. All of that information will help provide information to the engineers on the effectiveness of the procedure. Each crew doing the work should be trained to help explain the process to the public and also warn neighborhoods about flushing so that staining of laundry can be avoided.
- **Change to Lake Water** – The changes being made now to the water plant will not be the same changes required to treat lake water once it becomes available. A thorough analysis and plan needs to be made in preparation of that switch. This is going to need to include changes in how the plant is operated, like eliminating lime softening and reducing the dosages of many chemicals. Consideration will also have to be given to algae treatment when lake water is being used.
- **Operating Programs** – All of the changes discussed above are based on testing and techniques proposed by engineers and skilled operators of both LAN and Veolia. The staff will need further training and implementation of detailed protocols to successfully implement the changes and to ensure long-term success at the plant. This means the City needs to implement a series of programs to ensure success in these changes.
    - **Process Control Management Plan** (PCMP) – The amount of testing and resulting changes in chemical dosages, along with monitoring the impact on the water, will require a well-documented process that all operators follow. An example of this is jar testing, which is used by the operators to identify the most effective chemicals and dosages to optimize treatment. The staff understands the basic treatment process but needs further practice and training to become proficient in the use of routine process control to adjust for water quality. This is commonly referred to as a PCMP and is used as a standard operating procedure so that the operators on the day shift can communicate with the night shift, that operators are following the same treatment plan for water, that the adjustments are unified between different shifts and different people, that a desired water treatment quality is defined and variations from it signal alarms and that the staff knows what to do when the water quality setpoints begin to drift away from its desired quality levels.
    - **Lab QA/QC** – The operation of the water plant is dependent upon accurate lab results. Standard operating procedure needs to be set and lab technicians trained in that process. EPA and the State

set procedures and standards to be met and the staff should strive to meet those standards. The City has already purchased a TTHM analyzer but should also consider a TOC analyzer that can be an online continuous device to provide immediate information on influent and effluent levels of TOC. Part of the lab records should be historical review of data to help operators better understand the changes they make in the plant.

- **Maintenance Management** – The key to water equipment is having all the equipment effectively maintained and functioning properly. The current capital program is fixing many broken pieces of equipment and updating the plant to current standards. This however must be followed with a rigorous maintenance program that ensures the proper preventive maintenance, is able to predict when maintenance is needed to keep equipment functioning properly and responsive to changes in flows and source water quality.
- **Training** – The changes being suggested are new to the staff and as such training needs to be provided in what the changes involve, why they are being made, the impact on the water quality, and how best to run the plant. A good demonstration of skill level is for the staff to become certified by the State as a licensed water plant operator. Many utilities now require all operators to hold at least the minimum certification level as a starting point and offer incentives to increase their certification level.

- **Communication Program –** The city should lay out an immediate, written strategy for communicating with the public in the short-term, as well as a 6-to-12 month strategy that contemplates known, future events like the KWA pipeline and switch to lake water. A wide range of activities are underway to work with the public but a comprehensive and coordinated effort, with a strategic focus, will help the utility and its customers.
  - **Dedicated Communications Personnel –** The City has a single, dedicated public information officer, tasked with providing service to all of city government. The current focus on communications support for Public Works, and the anticipated needs over the next several years, indicate the city would benefit from the hiring of a staff person in Public Works who could establish a communications program designed to provide clear and concise information to a broad audience though a number of different channels. In the interim, the city could hire a communications intern, local communications firm, or somebody with experience who is able to provide reduced or no-cost services for the immediate future.
  - **Communications Planning – Public Notification** – The City should be congratulated on its efforts to keep the public informed. It is posting its monthly reports on the web page to provide transparency, though these reports are highly technical – and may be too technical for the customer base at large. They are valuable to those customers who do want this level of detail. The city should create a single-page dashboard of information that outlines the water utility's performance for the previous month, post the dashboard on the website, print copies for distribution at customer service or other reception areas, and be provided during speaking engagements or other events. This dashboard should be easy to understand, and include:
    - The number of water quality tests conducted the previous month
    - The number of violations reported

- Whether these results are in or out of compliance
- Information about other proactive measures such as main and hydrant replacements, or other programs to improve performance of the water utility
- Benchmarking information so the reader has a greater understanding of how Flint compares with other similar utilities in the region and across the country

- **Public Meetings –**There should be additional, proactive coordination with neighborhood, community and civic groups to provide speakers on timely topics. Given the list of numerous responsibilities, the Public Works director cannot do it alone – the city should identify three or four other staff members, knowledgeable about the water utility who can also speak to various groups, provide information and answer questions. The development of an outreach strategy to target key neighborhood, community and civic groups also will advance the communications effort and the dissemination of information in both the short and long term.
- **Standard tools** – Work crews in the field are often the faces of the utility – the city should create standardized tools for communicating with the public that can be easily and quickly delivered to the community in the event of main breaks, flushing or pre-planned capital improvements. Tools should include:
  - Door hangers for individual distribution
  - Yard signs with simple messaging to be placed near work-sites
  - A simple tri-fold brochure with useful information about the utility and appropriate contact information
  - Specific flyers about a range of topics
  - Infographics about how the water system works, from the intake to the customer's site
- **Change in Billing Format –** The City currently has no real way to reach all customers on a regular basis and provide information. The city should consider changing from a billing postcard to using an envelope and bill stuffer. Monthly or bi-monthly bill inserts are typically used to provide educational material for customers and are standard ways to provide information. Understandably, budget considerations must be taken into account.
- **Use Public Affairs Programming and Opportunities –** The news media has been covering this topic quite extensively – there are other media-related opportunities that may reach a wider audience. Taking advantage of these opportunities will help the city relay information to its customers and the community.
  - Participate in regular editorial-board meetings to provide background information and updates on key milestones or events.
  - Identify a local weekly television program and offer to provide guests to speak about key milestones or upcoming events.

Conclusions and Next Steps

The focus of this report is to help assure TTHM compliance and then improve general water quality. The City had good results in its most recent TTHM tests, although that is to be expected with the changes made to date and the cooler weather which contributes to low TTHM formation. Warm weather will be a different situation both in the nature of the Flint River water quality and in the formation of TTHM. With those changes coming, the City needs to act quickly to make improvements before additional testing takes place this spring and summer. The summary below provides the recommended actions, a priority for their implementation and projected costs either operational or capital. The costs are rough orders of magnitude and will vary with changes in water quality, operational decisions, and engineering choices being made and in some cases require State approval. Although a priority is assigned many of these actions can take place simultaneously.

Priority	Action	Annual Operational Cost	One Time Capital Cost
1	Implement operating programs for process control, lab QA/QC, maintenance, and training. These programs are needed regardless of the TTHM issue and will help with transition to lake water. The City has decided upon a central maintenance software and the water system should be the first to utilize this program since costs are already budgeted. These programs should be initiated immediately.	$ 25,000	$ 250,000 - $ 350,000
2	Contract with your engineer and initiate discussions with the State on the reduction of chlorine prior to the filters and changing the filter media to GAC. This activity has the longest time frame for design and approval, but also is extremely critical to assuring reduced TTHM production. The current filter cleaning and maintenance project needs to be adjusted to take into consideration the change in filter media both to dispose of the anthracite instead of cleaning and to install the GAC. This entire project needs to be done by early July to assure a flow of water throughout the system. Several months are required for the engineering design, State approval, bidding of work and installation of GAC and as such needs to begin now.	$ 0	$1,500,000
	Contract with your engineer and initiate discussions with the State on the addition of 0.5 to 1.2 mg/L of either potassium permanganate (dry) or sodium permanganate (liquid). This will take time to get approved and to implement. The use of liquid tanks at the raw water pump station may be the quickest and least expensive alternative for a temporary measure.	$ 160,000 - $ 320,000	$ 50,000

	Contract with your engineer and initiate discussions with the State on the addition of a corrosion control chemical. This action can be submitted and discussed with the state at the same time as the other chemical and filter changes saving time and effort. A target dosage of 0.5 mg/L phosphate is suggested for improved corrosion control.	$ 50,000	$ 50,000
3	Increase the ferric chloride dosage to 100 mg/L depending on river water TOC levels. (Lower TOC levels can be treated with less ferric chloride.) This change can be made now and is allowed by the State.	$ 1,000,000	$ 0
	Reduce the ozone feed rate to 5 mg/. This change can be done now and does not require State approval.	($50,000 – $100,000	$ 0
	Reduce the lime dosage to minimize hardness levels after softening. This will eliminate magnesium removal during treatment, but will also reduce total hardness. A reduction in carbon dioxide dosing for recarbonation treatment also is expected due to the reduction in lime feed. This change can be made now and does not require State approval.	($270,000)	$ 0
4	Confirm with the engineer when the revised hydraulic model will be completed and if necessary for time to focus on areas of longest water age if that would speed up the effort. Identify impact of reducing tank levels or eliminating a tank seasonally to improve water age. Include with this effort a list of hydrants to flush along with time required to assure drawing fresh water through the system. The engineer has been assigned this task already and confirmation of the timing of a delivery is needed.	$ 0	Already Contracted
	Ask the engineer to identify closed valves on a map that are impacting water age and that can be bid for replacement as soon as weather permits. Have the engineer identify areas of the system where the valve contractor should be focused on finding and fixing closed valves.	$ 0	Already Budgeted
5	Implement the recommendations in the communications program including a person assigned to public works education, using envelopes instead of cards along with bill stuffers for education and provide training for staff. Envelopes and bill stuffers are expensive and might be done periodically and not every month. The cost of TTHM notices, Annual Water Quality Reports and City notices should be figured into if any additional costs would exist. Many of these changes are underway now by the City.	Position Being Budgeted	

Notes

- The costs provided are rough order of magnitude which final engineering will firm up but will fluctuate with final decisions on engineering, operating technique and water quality.
- The change from river to lake water will dramatically cut the chemical costs as less is needed once the change occurs. This means that potassium permanganate will likely not be needed, ferric will drop as much as it went up, ozone levels will be lower and little lime will be needed.

Results Expected

The real question is what changes can be expected from these results in lowering the TTHM, improving the aesthetics and preparing for the change to lake water.

- **TTHM** – The City has already made great strides in reducing the TTHM levels with the changes already made. The additional suggestions by Veolia will further reduce TTHM in the water and help get the city released from the notices being provided to customers.
- **Hardness** – The hardness entering the plant this winter is 360 mg/L with the current system reducing it to 210 mg/L and optimization will reduce to about 180 mg/L. During the summer the levels will be lower probably in the 140 mg/L to 150 mg/L range. The target set by the current best operating practices is 120 mg/L to 150 mg/L.
- **Discolored Water** – The discolored water is caused by the old unlined cast iron pipe. The water from the plant can have an impact on discolored water, but a greater concern is the breaks and construction work that disrupt the flow of water causing discoloration. A polyphosphate is suggested to help bind the old cast iron pipe reducing instances of discolored water. This along with improve flow of water and programmed hydrant flushing will help, BUT WILL NOT eliminate discolored water occurrences.
- **Change to Lake Water –** The recommendations include the suggestion of programs to help the staff better manage the treatment process, additional testing to adjust the plant and additional lab monitoring, a maintenance program focused on keeping equipment properly functioning and more training for staff to improve their skill level. Those actions will prepare the staff for the change of water sources when it comes next year in addition to developing a thorough plan for the switch.

Resourcing the world

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EXHIBIT II

LOCKWOOD, ANDREWS & NEWNAM, INC.

FINAL

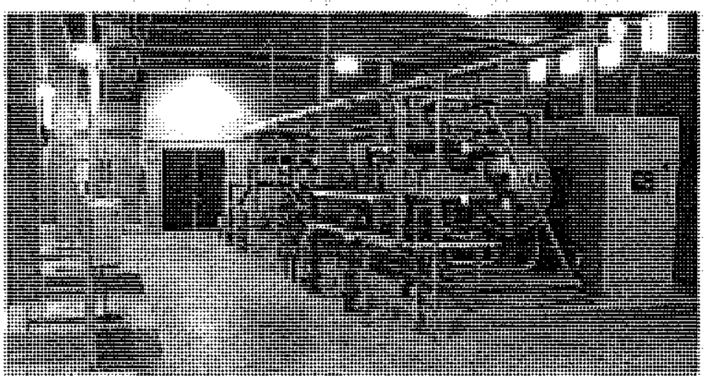
Operational Evaluation Report

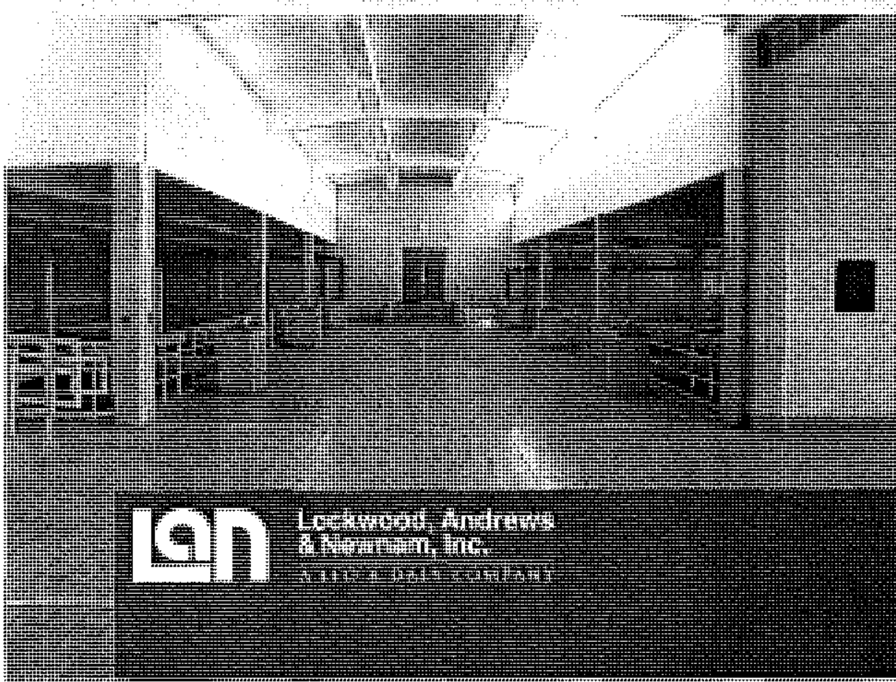
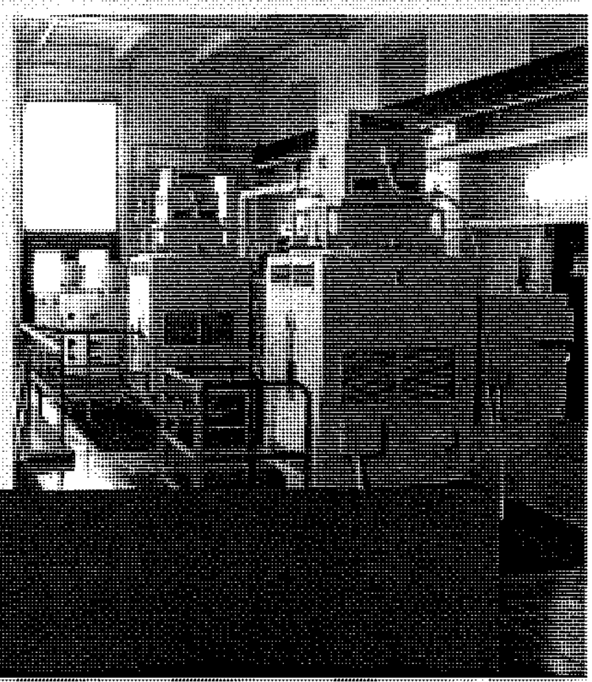
City of Flint

CITY OF FLINT, MICHIGAN 1855

Trihalomethane Formation Concern

August 27, 2015
In Response to May 2015 Sample Results



Lockwood, Andrews & Newnam, Inc.
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EXECUTIVE SUMMARY

Environmental Protection Agency (EPA) and Michigan Department of Environmental Quality (MDEQ) regulations require that public water suppliers test drinking water quarterly throughout the distribution system for disinfectant by-products (DBP's). Two categories of DBP's, tri-halomethanes (THM) and halo-acetic acids (HAA5), are regulated and must be tested for. The City of Flint began operation of their water treatment plant (WTP) full time with the Flint River as the source on April 25, 2014. Since that time, six quarters of samples taken have resulted in annual average violations for total THM. Prior to the first violation (Nov. 2014), the City hired Lockwood, Andrews & Newnam, Inc. (LAN) to complete this Operational Evaluation Report (OER) in conformance with EPA guidelines with the goal to determine the cause(s) of high levels of THM and evaluate possible solutions.

The EPA promulgated the Stage 2 Disinfectants and Disinfection By-Products Rule (DBPR) in January 2006 which set maximum contaminant levels (MCLs) for total trihalomethanes (TTHM) and HAA5 based on an annual running average, tested quarterly, for a given sampling location. The City of Flint reports levels from 8 sampling test locations. Of the six quarterly sampling cycles since Flint began operating the WTP full time, HAA5 levels have been acceptable but TTHM levels have exceeded the MCL. One sampling site was in violation following the May 2015 sampling cycle and results from August 2015 sampling indicate all sites are now within compliance.

A number of issues were identified as possibly contributing to the initial high THM levels measured.

1. Inefficient ozone system functionality which led to in increased chlorine feed.
2. Upstream source influences in terms of increased chlorine demand.
3. Bypass stream around softening contributed to chlorine demand and increased total organic carbon (TOC) levels in the effluent.
4. Unlined cast iron pipes in the distribution system contributing to chlorine demand.
5. High water age in the distribution system due to:
    a. Broken valves causing less than ideal flow patterns
    b. Inefficient pump station pressure zones
    c. Water storage volumes in excess of that needed for today's demands
    d. Oversized water mains
    e. Low water demands
6. High chlorine demand in filters.
7. High THM formation potential (THMFP) in source water.
8. Less than optimal removal of THM precursors.

A graphical representation of how the factors above relate to the timing of THM compliance sampling is shown as Table 1. Compliance sampling dates are hatched. Each row in Table 1 describes a factor that can lead to increased THM levels and the table defines when each of those factors applied. Note the convergence of nearly all factors around the second sampling period on August 21, 2014 to create what appears to have been a worst case scenario. The table also shows that the factors listed as those that the City can control have been addressed prior to 2015 sampling periods. Monthly operating report data up to August 1, 2015 is depicted on the Table.

TABLE 1 - SUMMARY OF NEGATIVE INFLUENCES ON THM COMPLIANCE SAMPLING

Year	FACTOR	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
2014	Softening bypass stream over 20% of plant flow												
2014	Ozone system not feeding optimally												
2014	Using full water storage capacity of WSR & CSR												
2014	Chlorine feed at WTP 7.0 mg/l or more												
2014	Ferric chloride feed rate less than 10 mg/l Fe^{3+}												
2014	Raw water temp 23 degrees C or more												
2014	Raw water TOC levels above 8.0 mg/l												
2014	Raw water coliform over 5000 counts/day												
2014	Positive bacteria test in dist. system (boil water notice)												
2014	Water demand less than 15 mgd												
2015	Softening bypass stream over 20% of plant flow												
2015	Ozone system not feeding optimally												
2015	Using full water storage capacity of WSR & CSR												
2015	Chlorine feed at WTP 7.0 mg/l or more												
2015	Ferric chloride feed rate less than 10 mg/l Fe^{3+}												
2015	Raw water temp 23 degrees C or more												
2015	Raw water TOC levels above 8.0 mg/l												
2015	Raw water coliform over 5000 counts/day												
2015	Positive bacteria test in dist. system (boil water notice)												
2015	Water demand less than 15 mgd												

Dates of occurrence
Expected dates of occurrence based on past data
Compliance sampling date

Factors under Flint staff control
Flint River characteristics
System factors

ACTION PLAN

The City of Flint has signed an agreement with the Karegnondi Water Authority (KWA) to purchase raw water drawn from Lake Huron. The KWA system is currently under construction and expected to be operational by late 2016. The water supply from Lake Huron will have entirely different water quality characteristics from the Flint River and those characteristics are expected to yield drastically reduced DPB formation. With that, non-structural options to help reduce THM levels are much preferred over solutions requiring new construction. Therefore, two categories of actions have been devised: Stage 1 being actions that can be completed relatively quickly without major construction and Stage 2 consisting of either long term actions or solutions requiring major construction. The City is actively working to complete Stage 1 actions as soon as possible. Stage 2 actions are to be implemented only if Stage 1 actions are ineffective in adequately reducing TTHM levels and therefore Stage 2 is contingent upon the outcome of Stage 1. As of the date of this report, status updates for action items are shown in red.

Stage 1 – Immediate Actions

- Hire third party water quality expert to complete independent 'water audit'
    - The City hired Veolia Water to review all water quality related operations, procedures, actions taken and planned responses. Recommendations from Veolia were provided in a report and technical memo dated 3/12/15 and 3/30/15 respectively.
- Obtain an in house THM analyzer to allow regular operational monitoring of THM levels
    - THM analyzer was installed 2/17/15.
- Hire ozone system manufacturer to troubleshoot ozone system
    - Manufacturer and controls programmers performed on site evaluations followed by corrective modifications in January 2015.
- Bench scale jar testing
    - Match existing process and assess possible areas of improvement
        - Existing process was simulated and an evaluation of existing chemical feed dosages was completed by LAN.
        - Existing process TOC profile was developed by Veolia.
    - Simulate potential modifications to treatment process
        - Soda ash softening evaluation completed and PAC feed testing was completed by LAN.
    - Evaluate coagulation and flocculation polymer aid feeds to assist with TOC removal
        - Evaluations of polymer aids completed by LAN and PVS Technologies.
- WTP operational changes
    - Discontinue softening bypass stream to reduce chlorine demand
        - Operational directive has been set to soften no less than 80% of flow.
    - Disinfection of filter beds to reduce chlorine demand
        - Utility Service Group contracted by City and condition assessment completed. Controls improvements have been completed.
    - Begin coagulation and flocculation polymer aid feeds to assist with TOC removal if bench scale test results are positive
        - Jar testing completed to date has not indicated a meaningful benefit to feeding coagulation/flocculation polymer aids. Increased ferric doses have been implemented at the WTP based on positive jar test results.

- Increase water main flushing efforts to minimize stagnant water
  - Flushing efforts are ongoing as needed based on chlorine residual levels measured in the system.
- Water system modeling to identify areas with high water age and potential solutions
  - The water model has been improved and preliminary results, including system wide water age, have been produced. Water demand updates and reconciliation with operator's data are underway with expected completion in mid June, 2015.
  - Cedar Street Pump Station potential recirculation
    - Water model analysis to be completed Sept-Oct, 2015.
  - West Side Pump Station potential recirculation
    - Water model analysis to be completed Sept-Oct, 2015.
  - Storage tank volume use
    - Operating levels of West Side and Cedar Street reservoirs have been lowered to reduce water age. Possible elimination of WS or CS to be evaluated Sept-Oct, 2015.
  - Possible broken closed valve locations
    - Model has been updated with known broken valve locations. Model results are being evaluated for indications of other possible broken valves. City has also initiated valve assessment program.
  - Locations in need of flushing
    - High water age areas have been identified in the water model. Further evaluation is expected to be done by November 1, 2015 to determine most effective flushing points.

Stage 2 – Contingent Actions

- Replace filter media with granular activated carbon (GAC) media
  - Filter anthracite media was replaced with GAC media July – August 2015.
- Fix ozone system
  - Repairs have been made to gauges and programming and the system is producing proper ozone and functioning under manual operation. Further minor repairs are planned for the 1st quarter 2015 to allow automatic operation.
- Start feeding coagulation and flocculation polymer aids to lower TOC, if not completed in Stage 1
  - Polymers evaluated by LAN did not demonstrate notable benefit.
  - PVS Technologies evaluated a proprietary polymer that showed little benefit.
- Convert to lime and soda ash softening
  - Option deemed unnecessary due to effectiveness of new GAC media.
- Change disinfectant to chloramine or chlorine dioxide until KWA
  - Option deemed unnecessary due to effectiveness of new GAC media.
- Install pre-oxidant feed (permanganate) at intake to optimize ozone disinfection
  - Option deemed unnecessary due to effectiveness of new GAC media.
- Implement advanced treatment for THM precursor removal
  - Option deemed unnecessary due to effectiveness of new GAC media.

- Increased main flushing based on water modeling results
  - Water model analysis to be completed Sept-Oct, 2015.
- Continue valve replacements with water model assistance
  - Water model analysis to be completed Sept-Oct, 2015.
- Emphasize cast iron pipes on water main replacement priority list
  - Flint has bid replacement of over 2 miles of 24" steel pipe along Dupont and Bishop Streets to be completed when and if the City can allocate funds. The water main section is considered a critical transmission main, and is expected to contribute to decreases in water age when complete.

THM samples have been taken and tested 6 times for regulatory reporting since the City began using the Flint River for supply. Numerous additional sets of samples have been taken by the City for internal operational monitoring. Compliance samples were taken in May 2014, August 2014, November 2014, January 2015, February 2015, May 2015, and August 2015. The average of all eight sample sites in August 2014 was 142.1 ug/l and the most recent average of samples taken in August 2015 was 63.6 ug/l. The MCL defined by the EPA is 80 ug/l.

I. BACKGROUND

The City of Detroit Water and Sewer Department (DWSD) has historically provided drinking water for the City of Flint and Genesee County. In the late 1990's growing concern regarding the reliability of the DWSD supply prompted the City of Flint to upgrade their existing water treatment plant (WTP). Those improvements, defined as Phase I, were completed in 2005 and were intended to allow the Flint WTP to operate, using the Flint River as the source, for an extended period of time in the event that supply from the DWSD was temporarily interrupted. Additionally, the Phase I improvements set the stage for Flint to break free from dependence on the DWSD supply and water charges over which they had no control.

A. WATER SUPPLY TRANSITION

1. Detroit Water and Sewer Department (DWSD)

Prior to spring of 2014, the Genesee County and Flint region had been provided drinking water by the DWSD. However, due to excessive cost increases and reliability issues with the DWSD system other options had to be explored.

2. Karegnondi Water Authority (KWA)

In 2010 the Karegnondi Water Authority (KWA) was formed for the purpose of developing a new water supply from Lake Huron to serve the region in lieu of the DWSD supply and the City of Flint elected to join. The KWA expects the new system which is currently being constructed to become operational by the fall of 2016.

3. Flint River – Interim Period

With a renewing water supply agreement between Flint and the DWSD being terminated by the DWSD (effective April 30, 2014) and the KWA system not expected to be operational until late 2016, the City of Flint decided to initiate operation of the existing WTP full time utilizing the Flint River as the interim water source. A variety of WTP improvements were necessary for the Flint plant to become a full time plant. For purposes of this report, Phase II improvements to the Flint WTP are improvements intended to allow the plant to operate full time with either the Flint River as the source or the KWA supply as the source.

B. TTHM VIOLATIONS

The EPA and MDEQ method of determining if TTHM sample results exceed the MCL uses a locational running annual average (LRAA). Flint's first TTHM violation was cited by the MDEQ following the third cycle of sampling completed in November 2014. Of the 8 sampling sites, 4 were in violation. At that time the MDEQ used the following calculation for determining if the MCL had been violated:

(2 x current quarter value + previous 2 quarter values) / 4 = Operational Evaluation Value

Flint has now completed tests for 6 quarters and a straight annual running average applies. Based on samples taken on August 18, 2015 there are no longer any sites in violation of the THM MCL limit. The August 2014 average across all test sites was 142.1 ug/l and the August 2015 average is 63.6 ug/l. Test results are tabulated in Table 2. HAA5 sample results are shown in Table 3, of which Flint has had no violations.

TABLE 2 – TTHM TEST RESULTS (ug/L)								
Sample Location	5/21/14	8/21/14	11/21/14	2/17/15	5/18/15	8/18/15	May/15 LRAA	Aug/15 LRAA
WTP Tap	56	86	33	-	~35	~25	n/a	n/a
1) 3719 Davison McDonalds	162.4	145.3	58.6	16.2	51.4	75.5	67.9	50.4
2) 822 S. Dort Hwy BP Gas Sta.	75.1	112.0	36.2	19.9	46.1	54.9	53.6	39.3
3) 3302 S. Dort Hwy Liquor Palace	111.6	127.2	33.3	16.8	63.5	53.2	60.2	41.7
4) 3606 Corunna Taco Bell	79.2	181.3	33.9	18.1	54.7	61.9	72.0	42.2
5) 2501 Flushing Univ. Market	106.4	196.2	93.6	24.5	59.8	70.6	93.5	62.1
6) 3216 MLK Salem Housing	82.2	112.4	50.1	28.5	72.7	90.3	65.9	60.4
7) 5018 Clio Rite Aid	88.2	144.4	53.6	19.2	60.5	59.5	69.4	48.2
8) 6204 N. Saginaw N. Flint Auto	96.5	118.3	41.1	14.9	45.2	42.6	54.9	36.0

TTHM MCL = 80 ug/l

TABLE 3 – HAA5 TEST RESULTS (ug/L)								
Sample Location	5/21/14	8/21/14	11/21/14	2/17/15	5/18/15	8/18/15	May/15 LRAA	Aug/15 LRAA
WTP Tap	36 (taken June 14, 2014)						n/a	n/a
1) 3719 Davison McDonalds	64	43	16	9.0	16	15	21.0	14.0
2) 822 S. Dort Hwy BP Gas Sta.	38	40	21	9.0	16	11	21.5	14.3
3) 3302 S. Dort Hwy Liquor Palace	52	31	15	9.0	17	14	18.0	13.8
4) 3606 Corunna Taco Bell	50	24	15	9.0	16	13	16.0	13.3
5) 2501 Flushing Univ. Market	55	17	24	9.0	15	13	16.3	15.3
6) 3216 MLK Salem Housing	41	25	5	2.0	10	2	10.5	4.8
7) 5018 Clio Rite Aid	49	30	17	9.0	22	15	19.5	15.8
8) 6204 N. Saginaw N. Flint Auto	48	37	18	9.0	17	10	20.3	13.5

HAA5 MCL = 60 ug/l

C. WATER TREATMENT PLANT RECENT IMPROVEMENTS & STATUS

1. Phase I WTP Improvements

Since 1965, the Flint WTP has remained a secondary or backup supply system to the DWSD primary supply. Typically the secondary supply for a public water system is expected to be needed only during emergency situations and normally is designed for short term operation such as providing the average daily demand for a few days. Conversely, Phase I improvements were designed with the intent to upgrade the Flint WTP in order to allow for an extended short term period (6 weeks) because of the perceived high risk that the DWSD supply would fail and remain out of service for an

extended duration. Regardless, the Flint WTP was still intended to serve as a standby plant and as such the Phase I improvements lacked redundancies that would be required for a primary supply WTP.

2. Past Pilot Study & Testing

During design of the Phase I improvements a treatability study was completed by Alvord, Burdick & Howson, LLC (AB&H) in 2002. The Treatability Study evaluated the current treatment processes that are in place at the Flint WTP today with the Flint River as the source. The report recommended the following:

TABLE 4 – 2002 WTP TREATMENT RECOMMENDATIONS

Treatment	Purpose	Point of Application	Dosage (mg/l)
Sodium permanganate	Zebra mussel control	Intake	0.3
Ozone	Taste & odor removal, disinfection	Diffusor basin	1.5
Ferric chloride	Coagulation	Rapid mix	40
Coag aid polymer	Turbidity & TOC removal	Rapid mix	2.0
Floc aid polymer	Turbidity & TOC removal	Floc basin	0.05
Lime	Softening	Softening basin	175
Soda ash	Softening	Softening basin	52
Carbon dioxide	pH adjustment	Recarb basin	37
Media filters	Filtration	N/A	Na
Chlorine	Disinfection	Filter effluent	1.0

Of the recommended items, zebra mussel control, coagulant and flocculation polymer aids, and soda ash feed have not been incorporated into the treatment process.

3. Phase II WTP Improvements for Full Time Operation

Phase II WTP improvements are those needed to convert the Flint WTP from a back-up supply to a primary supply plant. A number of improvements have already been constructed as they were necessary to operate full time when treating water from the Flint River. The improvements under the title of Phase II that have been completed or are nearly complete include installation of the future raw water feed connection point and valving for the KWA supply, upgrades to the lime sludge lagoon, the lime sludge lagoon decant and disposal system, decant pump station and force main, installation of mid-point chlorination before filtration, new oxygen / nitrogen storage facilities for the ozone system, and upgrade of the electric feed sub-station.

Additional improvements to the Flint WTP that are to be completed to become part of the normal treatment process using water supplied by the KWA are:

- New coagulant feed system
- Electrical
  - Pump Station #4 upgrades (under construction)
  - SCADA and controls upgrades
  - Filter transfer pump station feeders
- Pump replacements and VFD installation in the low and high service pump station (under construction)
- Filter transfer pump station to Dort Reservoir
- Facility security improvements

II. SOURCE WATER EVALUATION

A. DATA ANALYSIS

Based on past data collected and the 2002 Treatability Study by AB&H, the Flint River water quality varies seasonally with higher hardness and alkalinity experienced in the winter. Higher magnesium concentrations are also experienced in the winter, adding difficulty to the settling process due to neutrally buoyant floc. General water quality average characteristics recorded for the 2002 Treatability Study as compared with average characteristics recorded in 2014 are shown in Table 5 below.

TABLE 5 – FLINT RIVER WATER QUALITY CHARACTERISTICS

Period	Turbidity NTU	TOC Mg/l	Alk. Mg/l	Hardness Mg/l as CaCO3	pH	Total Col. Count/day	THMFP Mg/l
2001 Apr–Oct	7.9	9.4	215	272	8.1	870-1230 (7300 max)	410
2014 May–Oct	8.3	10.3 5/22/14	207	252	8.2	1900-9000 (48,300 max)	187

The Flint River characteristics do not appear to have changed significantly over the past 10+ years. Note that near the time Flint initiated withdrawal from the Flint River investigation by City staff revealed a sewer leak upstream of the plant that may have contributed to the total Coliform count. The leak was subsequently repaired.

B. CONCLUSIONS

Considering the minor changes in Flint River water quality, much of the information contained in the 2002 Treatability Study by AB&H remains relevant today. Data from that report assumed to be consistent today include the following:

- Flint River is influenced by groundwater from a dolomitic aquifer
- Hardness varies seasonally with higher hardness and alkalinity in the winter
- Hardness, alkalinity, magnesium concentrations tend to be reduced by run-off

In development of the 2002 Treatability Study, processes were simulated which resulted in low THM levels. Therefore, information contained in that report was used to assist with establishing a baseline jar testing procedure as discussed further in Section III.

III. TREATMENT PROCESS EVALUATION

A. EXISTING PROCESS DESCRIPTION

The existing WTP consists of an intake with screening from the Flint River, low lift pumping, ozonation, rapid mix, flocculation, settling, softening, recarbonation, filtration, storage and high service pumping. A process diagram is shown as Figure 1.

1. Intake
A 72" diameter pipe draws water from the Flint River through 2 traveling screens to the low lift pump structure. No chemicals are currently fed for Zebra mussel control or pre-oxidation as recommended by the 2002 Treatability Study. Manual removal of zebra mussels is more economical than installation of chemical feed equipment considering the short term need.

2. Ozone
There are 2 ozone generators designed to provide adequate ozone for a WTP flow of up to 36 mgd. There are 3 ozone contact basins. The ozone generators were designed to produce 900 lbs/day at 10% concentration and up to 1300 lbs/day at 6% concentration each. Prior to recent repairs, readings indicated a production rate of approximately 700 lbs/day at 4% concentration. It is possible that before the recent improvements the ozone feed might not have been optimized. In fact, it is known that less than optimal ozonation previously led to increased chlorine feed which would have contributed to THM formation.

3. Rapid Mix
East and West rapid mix chambers allow chemical feed prior to the flocculation basins. Each rapid mix chamber is equipped with a 5 hp mixer.

4. Coagulation / Flocculation
The WTP contains two equally sized flocculation basins, east and west, and each basin provides tapered or gradually slowed mixing from inlet to outlet. There are fifteen 2 hp mixers for each basin with VFDs to control mixing speed. The 2002 Treatability Study recommended feeding both coagulation and flocculation polymer aids. Neither polymer aid is being used today because turbidity and TOC removals have been sufficient to meet regulatory requirements.

5. Settling
Primary clarification takes place within 3 basins containing plate settlers. The settlers are operating as designed but are due for cleaning.

6. Softening
Again, there are two basins for softening: east and west. Each basin is 120' in diameter and contains a solids contact softening unit. Each softening basin/unit has a design capacity of 18 mgd. The east clarifier has an effluent weir imbalance that the City intends to fix when low demands allow for construction. Low lift pumping limitations, flow control to the basins, malfunctioning polymer feed pumps, control restrictions on residuals removal, and fluctuating demands have made it difficult for WTP staff to stabilize the softening process. Softening is accomplished by feeding lime. The decision was made by the City not to feed soda ash in order to remove non-carbonate hardness because acceptable hardness levels could be achieved with lime feed only and softening is short term until Lake Huron water becomes available. Lime and soda ash softening is a possible consideration to assist with TOC removal and thus reduce THM formation.

7. Recarbonation

Recarbonation for pH adjustment is accomplished in east and west recarbonation basins between and to the north of the softening basins. Carbon dioxide storage and feed equipment is located west of the recarbonation basins.

8. Filtration

Filtration is accomplished with 12 dual media filters, equally sized and designed to filter 3.0 mgd each. Sand and anthracite media was replaced in July and August 2015 with new sand and GAC at depths of 12" and 18" respectively. Prior to spring of 2014, the filters had been operated intermittently over the years due to the standby nature of the WTP and until recently, chlorine injection took place downstream of the filters. It is possible some microbial growth had developed in the filters leading to increased chlorine demand which could have contributed elevated TTHM. Late 2014, the City recently hired a contractor to upgrade the electrical controls for the filters and that work has been completed.

9. Disinfection

Disinfection is provided by ozonation and by feeding chlorine. Ozonation occurs at the front end of the WTP. Chlorine is fed prior to filtration and prior to finish water storage / high service pumping. The intermediate chlorine injection location was recently constructed under the Phase II, Segment 1 contract.

10. Clear Well & Pumping

The pump building sits adjacent to a 3 MG clear well and contains both low and high service pumps.

B. JAR TESTS / EXPERIMENTS

1. Approach

There are several well practiced methods by which DBPs can be reduced. First, the disinfectant can be changed to an alternate that has a lower tendency to form DBPs. Second, additional treatment systems such as activated carbon or air stripping (depending on the nature of the precursors) can be added to remove DBP precursors. Lastly, the existing treatment processes can be optimized to remove as much DBP precursor as possible. Of these options, optimizing existing treatment processes is the only strategy that does not require the construction of new and expensive facilities. It is anticipated that Flint will be receiving Lake Huron water by late 2016 and this water will have a completely different chemistry from the Flint River. Major process changes instituted to address THM levels using Flint River water are likely to be unnecessary for Lake Huron water and may even be inappropriate. Therefore, those options which require addition of new treatment processes are undesirable at this time. In recognition of this upcoming change in water source, efforts for this study have concentrated on improving the existing processes, rather than adding new ones. New treatment processes will only be recommended if operational changes to the existing treatment train prove ineffective.

Recent sample test results suggest that most of the DBPs are formed in the distribution system rather than within the treatment plant. Therefore, the most logical approach is to reduce the DBP formation potential (DBPFP) rather than simply lowering the levels of DBPs leaving the plant. During bench scale testing, formation potential (FP) levels were the primary indicator of success or failure of proposed process modifications.

2. Protocol

Bench scale pilot testing is intended to reflect actual plant operating and hydraulic conditions so the bench scale treatment units were sized based on various dimensionless factors to ensure the pilot treatment matched the actual system. Bench scale ozonation was not practical due to time and cost limitations. Therefore, water samples were withdrawn from the plant ozone basin effluent. These samples were transported to the laboratory and dispensed into square testing jars. The jars were used to simulate rapid mix, three-stage flocculation, and settling. Rapid mix and flocculation conditions were matched to the plant based on "Gt" values. The "G" value is a measure of the mixing intensity and is a function of mix time, viscosity of the liquid, and mixing power applied to the water. "Gt" then, is a size scaling factor where time has been accounted for. Settling time was scaled to match the shorter settling depth of the testing jars. After settling, samples were decanted from the test jars. The decanted samples were then lime softened; softening conditions were similarly matched on the basis of "Gt". Carbon dioxide was sparged into the samples to reduce the pH. The water was then vacuum filtered through filter paper, sized to simulate the plant's dual media filters. The samples were dosed with excess chlorine and allowed to react for seven days at 25° C before testing for DBPs to determine the formation potential.

The following conditions were applied during testing to properly match small scale testing to actual plant processes.

TABLE 6 – BENCH SCALE TEST MIXING INTENSITIES

Process	G	Duration	Mix RPM
Ozonation	Plant	-	-
Rapid Mix	200	44 sec	160
Flocculation, Stage 1	50	9 min	55
Flocculation, Stage 1	25	9 min	30
Flocculation, Stage 1	12	9 min	19
Settling	N/A	10 min	-
Softening	TBD	10 min	-
Recarbonation	N/A	N/A	-

The primary variables during testing were chemical additions and chemical dosages. Specific chemicals and dosages used for initial testing conditions were selected to reflect current plant usage and the recommendations of the 2002 Treatability Study:

TABLE 7 – BENCH SCALE TEST CHEMICAL FEED RATES

Chemical	Current Usage	2002 Study	Test Values
Ozonation	4.66 mg/l	1.5 mg/l	
Ferric Chloride	7.7 mg/l Fe3+	40 mg/l Fe3+	7.7 – 80 mg/l Fe3+
Coagulant Aid Polymer	Not used	2.0 mg/l	1 – 2 mg/l
Flocculation Aid Polymer	Not used	0.05 mg/l	0 – 0.05 mg/l
Powdered Activated Carbon	Not used	N/A	20 – 100 mg/l
Lime	120 mg/l	175 mg/l	120 – 175 mg/l
Soda Ash	Not used	52 mg/l	0 – 52 mg/l
Cationic Softening Polymer	3.13 mg/l	Not used	3.13 mg/l
Anionic Softening Polymer	0.88 mg/l	Not used	0.88 mg/l
Fluoride	0.45 mg/l	1 mg/l	Not used
Carbon Dioxide	32 mg/l	37 mg/l	Fed to reach pH of 7.5 +- 0.3
Chlorine	6.3 mg/l	1 mg/l	10 mg/l

3. Considerations

The 2002 Treatability Study did not note significant formation of DBPs. This may be a function of different Flint River water chemistry at that time. However, recognizing the considerable differences in chemical usage and dosages between that study and current operations, those differences in chemical use and dosage are an obvious starting point for optimizing treatment to prevent DBP limit exceedance.

Although it is believed that optimization of current treatment can correct the DBP issue, should optimization of present treatment prove insufficient, alternate residual disinfectants (chloramines and chlorine dioxide) could be investigated as additional treatment measures.

4. LAN Test Results

Two rounds of jar testing were completed by LAN during the weeks of December 15, 2014 and January 26, 2015. Detailed test data is included in Appendix A. Testing results can be summarized as follows:

- Increased dosages of ferric chloride resulted in higher reduction of THMFP.
- The currently utilized feed rate of lime at 120 mg/l is appropriate
- Softening with soda ash in addition to lime resulted in minor additional THMFP reduction – in the range of 0% - 10%.
- The benefits of using a cationic polymer during softening at a dosage range of 0.31 - 3.13 mg/l to help reduce THM's are unclear
- The benefits of using an anionic polymer during softening at a dosage range of 0.09 – 0.88 mg/l to help reduce THM's are unclear
- Feeding PAC was ineffective in reducing THMFP within the dosage range of 20 – 100 mg/l.

5. Testing by Others

In addition to jar testing completed by LAN, the chemical supplier who provides ferric chloride for the City, PVS Technologies, ran tests using their recommended flocculant polymer aid. Plus, Veolia Water completed jars testing of their own the week of February 16th to analyze other process details and current WTP parameters. Experiments completed by PVS Technologies showed very little TOC removal beyond that obtained with straight ferric chloride feed.

6. Conclusions

Increasing the dose rate of ferric chloride is an operational change that can easily be implemented without the need for any additional equipment. Test results show that over 40% THMFP removal can be obtained with a dosage of 60 mg/l Fe^{3+} or higher. Increased dosing of ferric chloride would be most ideal coupled with regular raw water TOC monitoring so that TOC levels would dictate the appropriate ferric chloride feed rate.

Softening with soda ash in addition to lime is another option the City should consider if increased ferric chloride doses are not adequate to maintain THM levels under the MCL, particularly during warmer months. Again, monitoring of TOC in the raw water could provide useful information of when lime/soda ash softening is necessary.

IV. DISTRIBUTION SYSTEM EVALUATION

EPA guidance for the distribution evaluation portion of an OER is focused on identification and isolation of a specific portion of the distribution system that led to the exceedance. The circumstances of Flint's apparent pending TTHM exeedances are unusual in that a new supply has been implemented which clearly corresponds to the high TTHM sample results. Although the new source is one element in increased TTHM levels, value remains in evaluating the distribution system since water age is also a critical factor. Additionally, there may be distribution improvements that can be made to help alleviate the problem.

A. INFRASTRUCTURE

1. Piping

According to the most recent MDEQ Sanitary Survey, the distribution system is estimated to contain 70% cast iron, 20% ductile iron, 2% concrete and 8% steel water mains. Based on discussions with City staff, the percentage of cast iron pipe may be higher than that stated in the MDEQ Sanitary Survey. Unlined cast iron pipe can become pitted, allowing colonization sites for microorganisms leading to chlorine demand. Additionally, much of the piping in the system is aged and in poor condition. Increased chlorine demand could be resulting from biofilm in older pipes and from main breaks/repairs. The extent of contribution is not known but any water main replacement project will decrease chlorine demand somewhat if constructed properly. Unfortunately, water main breaks may also assist with decreasing water age by providing unintentional flushing. All things considered, it is impossible to quantify the impact existing piping has on THM formation without extensive research and long term study.

The City utilizes City Point software and GPS equipment to document main breaks and prioritize replacements. However, main break information is more pertinent to rusty water complaints and has little relevance to THM levels. Areas that have been targeted for main replacements include the transmission main from the WTP west to Dupont and south to the West Side reservoir, Fenton Road, Atherton Road, Dort Highway, Averil Street, and Boulevard Drive.

2. Storage

There are 4 finish water storage tanks and 1 raw water tank as tabulated below:

TABLE 8 – STORAGE TANKS

Name	Type	Water	Volume (MG)	Operating		Absolute	
				LWL	HWL	Bottom	OF
Dort Reservoir	Ground	Raw	20	-	-	730	750
WTP Tank	Elevated	Finished	2	883.0	896.0	863.0	898.0
WTP Clear Well – PS #4	Ground	Finished	3	11′	15′	708.5	726.0
Cedar Street Reservoir	Ground	Finished	20	-	11′	737.2	757.2
Westside Reservoir	Ground	Finished	12	-	12′	761.8	779.0

The MDEQ typically recommends providing a minimum finish water storage volume of 1/3 the maximum daily demand (MDD). According to the 2013 MDEQ Sanitary Survey, the 5 and 10 year MDDs are 21.57 mgd and 30.05 mgd respectively. A common rule of thumb for clear well storage volume at a WTP is 10% of the design flow rate. Another general guideline for reliability is to provide total storage to allow for 2 X the average daily demand plus fire flow demand. For this analysis, fire flow is assumed to be 2,500 gpm for either one industrial fire (2,500 gpm) or a combination of one residential (1,000 gpm) and one commercial (1,500 gpm) fire at a 4 hour

duration which results in a total volume of 600,000 gallons. These go-by approximations are summarized below with the applicable flow rates and are compared to the existing storage volumes currently being utilized.

Common Practice	Flow Rate	Recommended Volume by ROT	Volume In Use
Clear well 10% of Design Flow	18 MGD	1.8 MG	3.0 MG
Finish Storage = 1/3 MDD	30.05 MGD	10.0 MG	37 MG
Total Storage = 2 * ADD + FFD	13.87 MGD	28.3 MG	57 MG

Based on the values above, it appears the storage volume used in the Flint system could be decreased without negatively effecting reliability. The appropriate volumes of individual tanks will be further evaluated using the water system model and discussed in Section V (C).

All reservoirs have baffling to minimize stagnant water. Also, all tanks have been maintained and are in reasonable condition. The Westside reservoir has an exposed roof that is in need of rehabilitation, but its current condition has no influence on THM formation.

3. Pump Stations

All pump stations are in good condition but pumps are generally oversized. As an independent consideration, oversized pumps are not a contributing factor to high THM levels. Control of pumps and pressure zones are discussed in detail below.

B. OPERATIONS AND MAINTENANCE

1. Pump Station & Storage Operations

Pump stations and storage tank levels are controlled as shown in Table 9.

TABLE 9 – PUMP STATION CONTROLS

PS Name	Control Point	On Point	Off Point
PS No. 4 Raw	Operator	-	-
PS No. 4 Finish	Match plant flow	-	-
Westside	System pressure (elevated tank)	22.5′	33′
Cedar Street	System pressure (elevated tank)	22.5′	33′
Torrey Road	Distr. – Brown/Bradley	< 45 psi	> 45 psi

Prior to the first TTHM violation, Cedar Street and Westside pump stations were operated as needed and were alternated. Typically, Cedar Street was run in the morning and Westside was run in the evening and reservoirs for each were filled during low demand periods at night.

Westside, Cedar Street and Torrey Road pump stations are used to boost system pressure when high demands warrant it, but there are not well defined pressure zones within the system. Therefore, the possibility exists that water is being recirculated allowing for increased water age.

2. Booster Disinfection Practices

Booster disinfection is provided at the Cedar Street and Westside pump stations. When sustained residuals are not provided by chlorine feed at the WTP, sodium hypochlorite is applied at the reservoirs while being filled.

3. Changes in System Demands

Water demands in the City have been declining since the 1960's as the population has dropped. As a result, many of the water system components are oversized including storage tanks and water mains which both increase the time for water to reach the user.

From a short term perspective, Flint demands tend to increase in summer as is ordinarily expected but also in the winter due to water main breaks. The MDD for Flint often occurs in winter. Regarding THM formation, with lower temperatures and higher flows in the winter, THM levels taken at the distribution sample points are expected to be lowest for February sampling quarters than all others.

C. WATER SYSTEM HYDRAULIC MODELING

As part of this report, the City provided a hydraulic water model, originally developed by Potter Consulting, for LAN to update. Thus far, LAN has modified the model to be capable of extended period simulations, modified controls to reflect current operations, revised the piping to include known broken valve locations, updated pump curves, checked pipe diameters, updated system demands, and developed preliminary water age results throughout the entire system. Water age shown in the revised model corresponds for the most part to TTHM levels at the sampling sites. However, LAN has also identified several issues affecting the model that require further attention to allow for usable and reliable results. Those issues include accurate quantification of lost water and confirmation of the status of valves throughout the system. Preliminary water age results are presented in Table 10. Revised results will be provided when the hydraulic model has been fully updated.

TABLE 10 – PRELIMINARY WATER AGE FROM WATER MODEL

Sample Point	Location	Address	Water Age (Hrs)	May/15 LRAA THM (ug/l)
1	McDonalds	3719 Davison	25	68
2	BP Gas Station	822 S. Dort Hwy	18	54
3	Liquor Palace	3302 S. Dort Hwy	14	60
4	Taco Bell	3606 Corunna	340	72
5	Univ. Market	2501 Flushing	305	94
6	Salem Housing	3216 MLK	45	66
7	Rite Aid	5018 Clio	41	69
8	N. Flint Auto	6204 N. Saginaw	37	55

It is anticipated that topics shown below in italicized font will be detailed after the model is updated in Sept-Oct, 2015.

1. Simulation of Existing System

Match existing conditions. Chlorine and THM data may be used to verify model results. We have chlorine feed data at plant and residuals at 10 locations in each MOR, May 2014 – July 2015.

2. Identification of Water System Deficiencies

Specific issues to look at:

Water age in entire system
Possible recirculating water through pump stations
Use of storage tanks – volumes in particular
Indications of broken valves
Effectiveness of booster disinfection

V. RECOMMENDATIONS TO MINIMIZE FUTURE OEL EXCEEDANCES

A. SOURCE

The City of Flint has already committed to the change from the Flint River as the water source to Lake Huron under the KWA system, planned for late 2016. The risk of future TTHM limit violations will decline substantially with the use of water from Lake Huron due to much lower DBP precursors. It is important to recognize that the Flint River will become strictly an emergency supply when the KWA supply becomes available and any investments toward the Flint River should be contemplated accordingly. Recommendations discussed below in this section apply to the Flint River as the source.

Reverting to supply from the DWSD until the KWA supply is available as an option. However, based on information provided by the City of Flint, the annual cost to receive water from the DWSD would be at least $16,000,000/year or $1,333,000/month. Therefore, utilizing the DWSD for interim supply is cost prohibitive under the terms defined by the DWSD.

1. Watershed Management

A volunteer group entitled the Watershed Coalition performs various tasks related to managing the Flint River watershed such as spring cleanups and annual benthic studies to evaluate the river 'health'. No additional action is recommended at this time.

2. Monitoring

The City documents daily raw water flow, pH, alkalinity, carbonate and non-carbonate hardness, chloride, temperature, turbidity and coliform count as part of standard preparation of Monthly Operating Reports (MOR). WTP staff have obtained and installed TOC and THM analyzers. The THM analyzer is set up as an on-line plant tap monitor and operations personnel have begun taking samples most days to track TOC levels throughout the treatment process. It is recommended to implement TOC tracking as a strict daily procedure which would provide staff the data needed to establish correlations to predict distribution system THM formation.

3. Intake Operations

The 2002 Treatability Study recommended pre-oxidation in the form of sodium permanganate as a feed at the intake. It is possible the addition of a pre-oxidant such as hydrogen peroxide or some type of permanganate could enhance the ozone process. Veolia evaluated permanganate demand during jar testing the week of February 16th, 2014 and recommended implementation at a dosage of 0.5 mg/l – 1.2 mg/l to achieve 10% additional TOC removal.

4. Seasonal Strategies

Past data indicates the Flint River is influenced by groundwater and in particular, dolomitic spring water. The result is hard water with high concentrations of magnesium and sulfate. Also, hardness and alkalinity are higher during the winter. Upon initiation of supply from the Flint River, the City made the decision to soften with just lime to focus on removal of carbonate hardness. One potential modification that could assist with TOC removal and thus decrease THMFP would be lime and soda ash softening. A temporary caustic soda feed system is recommended to be put in place in case the need for optimized softening arises.

5. Upstream Contamination Issues

Upstream contamination issues are extremely difficult to prevent and even if detected are difficult to locate. Evaluation of raw water data collected for MORs is the easiest manner in which to detect upstream contamination issues because the data is already collected for treatment purposes. In fact, high total Coliform readings in the past have signaled potential issues that the City was able to identify and remove.

An upstream monitoring and warning system could be established to attempt to detect water quality issues or spill event type contamination early enough to adjust treatment procedures or cease intake prior to the contamination reaching the WTP. However, given the imminent conversion to the KWA supply, the period of full time use would likely be far too short to achieve payback on the capital expenditures.

B. TREATMENT PROCESS

1. Operational Recommendations

- Increase ferric chloride dosage: Previous testing in the 2002 Treatability Study, jar testing completed by LAN, and a review of 2014 ferric chloride dosages compared to THM levels leaving the WTP support that increasing the ferric chloride dosage would help reduce THM formation.
- Increased monitoring: Currently, the MDEQ does not require daily reporting of raw water TOC or finished water TTHM levels. However, daily tracking of such levels would allow the City to develop a correlation between the two, thus providing a predictive tool to help manage TTHM levels.
- Coagulation and flocculation polymer aids: The 2002 Treatability Study suggested the use of coagulation and flocculation polymer aids. These polymer aids were shown in the 2002 Treatability Study to increase TOC removal and thereby reduce THMFP but jar testing by LAN and PVS Technologies did not indicate clearly defined benefits. Addition of coagulation and flocculation polymer aids should be categorized as a future consideration that would require further evaluation.
- Discontinue softening bypass: In early summer of 2014 the City was bypassing a portion of flow around the softening basins because hardness levels did not warrant softening of the full stream. However, this practice was discontinued because it was believed the bypass stream was contributing to chlorine demand and preliminary data has supported that belief. Chlorine demand dropped 0.5 – 1.0 mg/l following elimination of the bypass stream in early November 2014.
- Soften with lime and soda ash: Research has shown that enhanced softening with both lime and soda ash may provide additional TOC removal. Veolia did not recommend this option after conducting jar tests.
- Disinfection of filter beds: Recommendation is no longer applicable since media has been replaced.
- Optimization of all existing treatment processes: Depending on bench scale testing conditions and results, slight modifications to all treatment processes might in order to replicate lower DPBFP.
- Discontinue or adjust softening anionic polymer feed: Some anionic polymers have been found to increase TOC. However, Veolia provided no recommendation to change polymers following their evaluation.

2. Infrastructure Change Recommendations

- Fix and/or replace faulty ozone equipment: Since the ozone equipment was installed it had not been used extensively on a full time basis. Following minor complications, the City hired the equipment manufacturer and a programmer to troubleshoot the system. Replacement of faulty gauges and redesign of the control program have allowed the system to operate properly since January 2015.
- Replace filter media with GAC media: GAC media could help reduce THM levels by reducing both TOC and chlorine demand. For this consideration, the intermediate chlorine feed location should be relocated to a point downstream of the filters. The City elected to pursue this option and 6 filters were completed in July 2015 and the remaining 6 were completed in August 2015. Provisions are also being considered for adding more GAC media and/or regeneration of media next summer.
- Change disinfectant to chloramine or chlorine dioxide: If other options prove to be ineffective, conversion to another disinfectant should be fully evaluated. Various characteristics of chloramination indicate an advantage over chlorine dioxide, but a full analysis would provide clarity as to which would be preferred.
- Install pre-oxidant chemical feed: Hydrogen peroxide or a form of permanganate as a pre-oxidant can enhance the activity of the ozone. Chemical feed could be installed at the intake structure or low service pump station, depending on the reaction time required. Use of a pre-oxidant at the intake might also provide the additional benefit of disinfection credit for ozonation with the MDEQ if an ozone residual can be obtained at the ozone process effluent as a result.
- Repair upstream sewer leak: a sewer leak upstream of the WTP intake was discovered in early summer 2014 and has been repaired by the City.

C. DISTRIBUTION SYSTEM

Potential distribution issues related to water quality issues discussed in Section IV included old cast iron pipe, oversized infrastructure, and remote storage/pump station locations and operations that might be less than ideal. Recommendations to address those issues are offered in this section.

1. Manage Water Age

a) Storage Tanks

Considering the excess storage capacity discussed in Section IV, in the short term it is recommended that operational changes be implemented immediately to reduce the overall volume of water stored to decrease water age. Immediate operational recommendations include lowering high water levels of reservoirs other than the elevated tank, to reduce the total system wide usable storage volume to 30-37 MG.

In the long term, LAN recommends development of the most ideal options for water model evaluation. Excess storage volume and tank locations within the water system afford Flint numerous options to reduce the amount of storage volume utilized. As a starting point, two recommendations are presented below.

Option 1
- Take West Side reservoir and pump station out of service
- Cut storage volume used in half at Cedar Street reservoir
- Adjusted system wide storage volume would be 35 MG

Option 2
- Take Cedar Street reservoir and pump station out of service
- Adjusted system wide storage volume would be 37 MG

b) Residence Time in Pipes

Completely redesigning and replacing the water system to match today's demands is not feasible financially and would be a waste of infrastructure with remaining useful life. Going forward, it is recommended that any future main replacement projects be evaluated for possible downsizing. When the water model is fully updated, it will provide a valuable tool in determining which mains can be downsized and to what extent. Replacement of broken valves and valve exercising are also recommended, which are programs that have already been implemented into Flint's regular operations.

Operationally, hydrant flushing is recommended as needed to minimize water age in low flow areas. Again, the updated water model should be used to locate high water age areas and optimal flushing points.

2. Reduce Disinfectant Demand

Recommendations to reduce disinfectant demand are similar to those described above to reduce water age. Replacement of old cast iron pipes would lead to a reduction of disinfectant demand on the distribution side, but realistically can only be accomplished over a prolonged period of time. In the meantime, hydrant flushing is the most viable means of reducing disinfectant demand in piping. From a storage standpoint, all reservoirs and tanks should be regularly inspected and maintained to prevent entrance of any outside contamination that would contribute to disinfectant demand. Cleaning of all tanks is recommended as well as investigation into stagnant water prevention options.

3. Water Modeling of Recommendations [yet to be completed]

Determine best flushing locations to reduce water age
Evaluate changes in storage tank operations to reduce water age
Valves to close/add to improve pressure zones, reduce recirculation
Optimization of pump station use – smaller pumps? Shut down?
Evaluate booster disinfection

D. BOOSTER DISINFECTION

Decreasing chlorine feed at the WTP and adding booster disinfection in the distribution system is an alternative intended to reduce the reaction time at higher concentrations of chlorine to reduce DPB formation. Extensive looping and branching within the existing system complicate how to best implement and utilize booster disinfection. Water system modeling is recommended to gage the effectiveness of existing feed point locations and dosages. Further discussion and details will be provided when the distribution evaluation results are available.

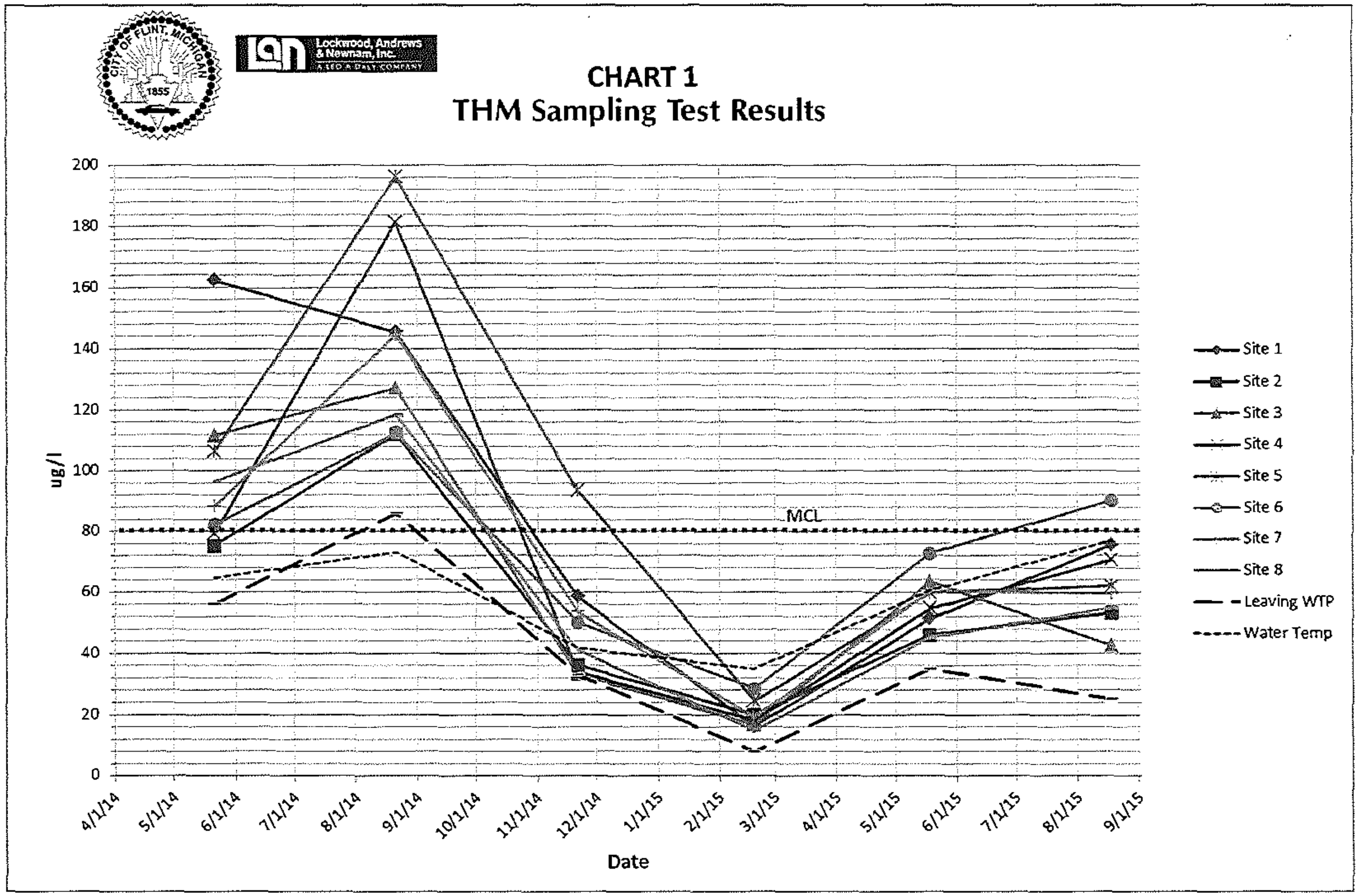
E. CATEGORIZATION OF ACTIONS

Considering that the Flint River is being used as the water source only until the KWA supply is available (expected late 2016), options to address high THM formation that require new construction or extensive time to implement are not preferred. On the other hand, the City understands THM sample results to date dictate that some action is necessary. Two categories have been developed to assist the City in prioritizing actions to take. Stage 1 consists of actions that can be completed relatively quickly without major construction and Stage 2 actions are either long term actions or solutions requiring major construction. Stage 1 actions are to be completed first followed by evaluation of the results prior to consideration of Stage 2 actions. Grouping of actions are shown in the table below.

TABLE 11 – ACTION PLAN

	Action	Purpose	Status
Stage 1	Hire water consultant to complete 'water audit'	Third party review of actions and operations to make sure no options are being missed	Complete
Stage 1	Increased water quality monitoring – obtain THM and TOC analyzers	Provide information needed to adjust WTP operations to match changing raw water quality	Complete
Stage 1	Troubleshoot ozone feed system	Reduce chlorine feed and increase TOC removal	Complete
Stage 1	Bench scale jar testing	Optimize treatment process and evaluate possible modifications	Complete
Stage 1	Discontinue softening bypass	Reduce chlorine demand	Complete
Stage 1	Disinfect filters	Reduce chlorine demand	Complete
Stage 1	Increased water main flushing	Reduce water age / stagnant water	Ongoing
Stage 1	Water system modeling evaluation	Determine areas with high water age and reasons	Partially complete
Stage 1	Modify booster disinfection feeds, if appropriate	Decrease water age	Not yet evaluated
Stage 2	Repair ozone system	Reduce chlorine feed and increase TOC removal	Complete
Stage 2	Continue increased water main flushing	Reduce water age / stagnant water	Ongoing
Stage 2	Replace filter media with GAC	Reduce TOC and chlorine demand	Complete
Stage 2	Continue valve replacements based on water model	Reduce water age / stagnant water	Ongoing
Stage 2	Convert to lime and soda ash softening	Increase TOC removal	Future consideration
Stage 2	Change disinfectant to chlorine dioxide	Reduce THMFP	Future consideration
Stage 2	Install pre-oxidant feed at intake	Optimize ozone disinfection, reduce chlorine	Future consideration
Stage 2	Implement coag. & floc. polymer aids, if appropriate	Increase TOC removal	Future consideration
Stage 2	Place priority on replacing cast iron water mains	Reduce chlorine demand	Ongoing

Samples were taken August 18th, 2015 for the latest round of quarterly testing. The City has implemented many of the Stage 1 actions and installed GAC media in the filters and THM test results have significantly improved (decreased) since May and August 2014. All sampling results are shown on Chart 1.


CITY OF FLINT, MICHIGAN
1855
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
CHART 1
THM Sampling Test Results
ug/l
0
20
40
60
80
100
120
140
160
180
200
MCL
4/1/14
5/1/14
6/1/14
7/1/14
8/1/14
9/1/14
10/1/14
11/1/14
12/1/14
1/1/15
2/1/15
3/1/15
4/1/15
5/1/15
6/1/15
7/1/15
8/1/15
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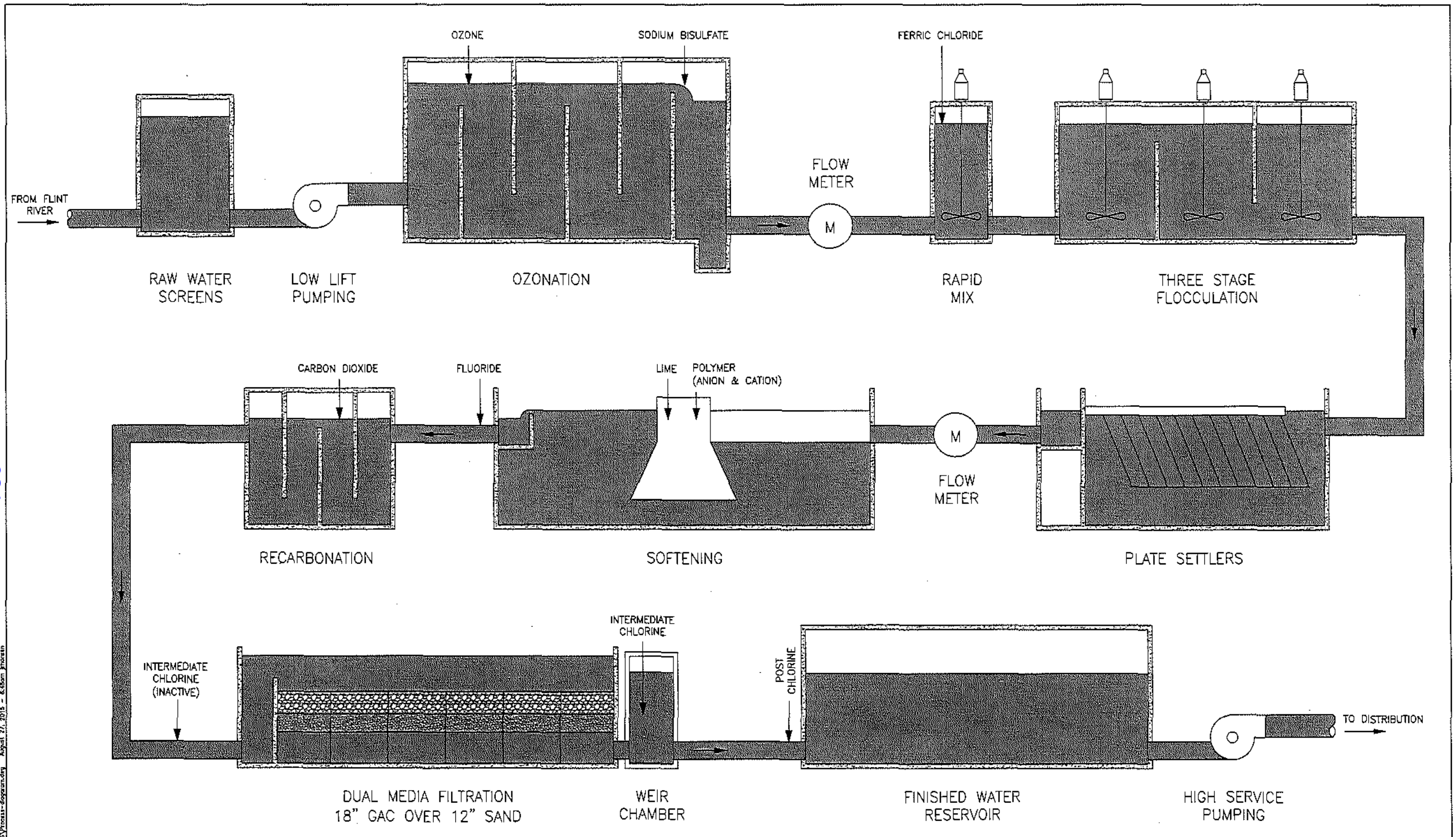
Date
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Site 7
Site 8
Leaving WTP
Water Temp



Genesee County

Lockwood, Andrews & Newnam, Inc.
1311 S. Linden Road, Suite B
Tel 810-820-2682 Fax 810-820-2703
www.lan-inc.com

CITY OF FLINT
WATER TREATMENT PLANT

REVISIONS

FILE LOG

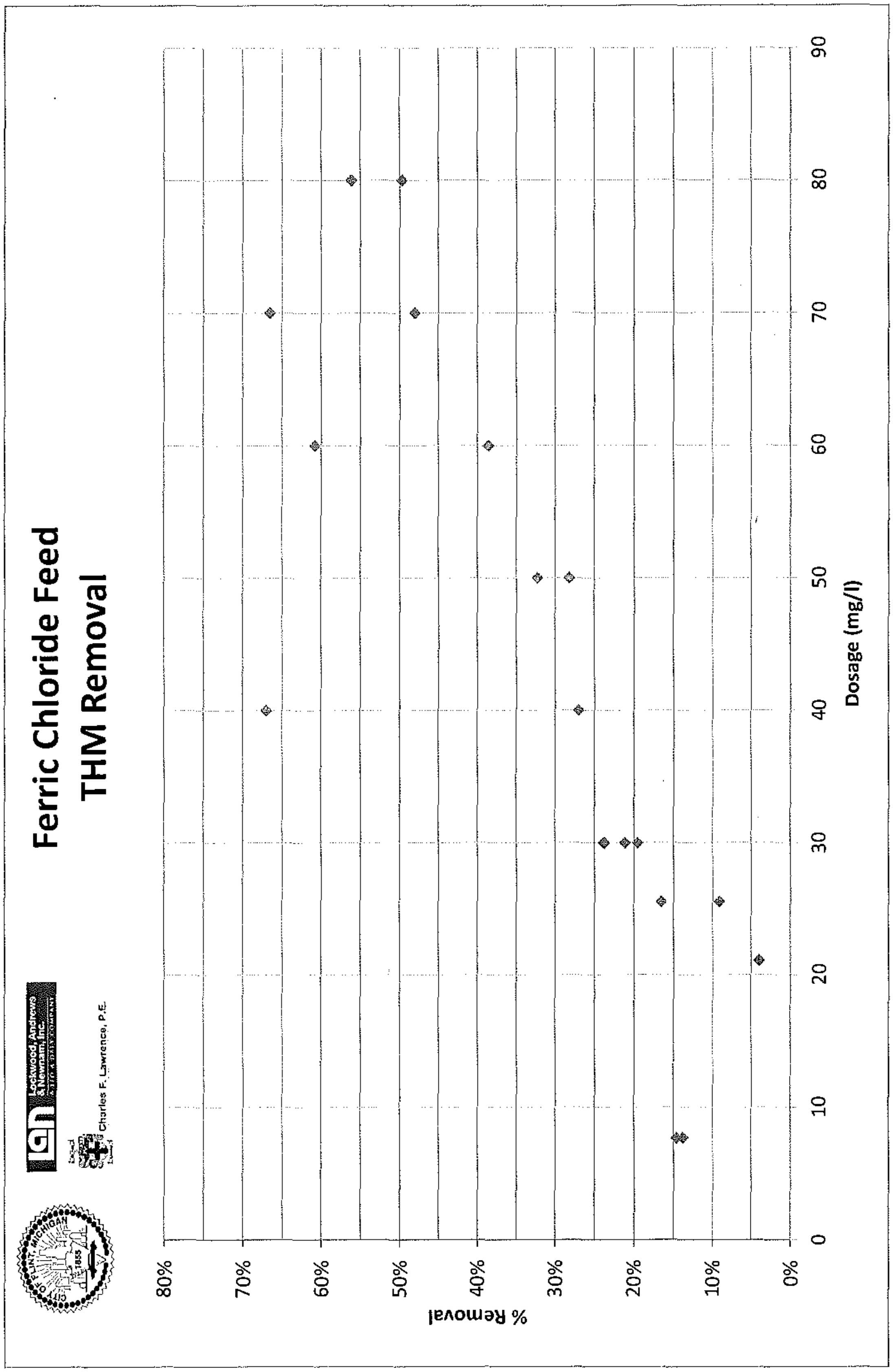
WATER TREATMENT PLANT
PROCESS DIAGRAM

Project No. 130-10701-001
Date Aug. 27, 2015

Sheet

FIG 1

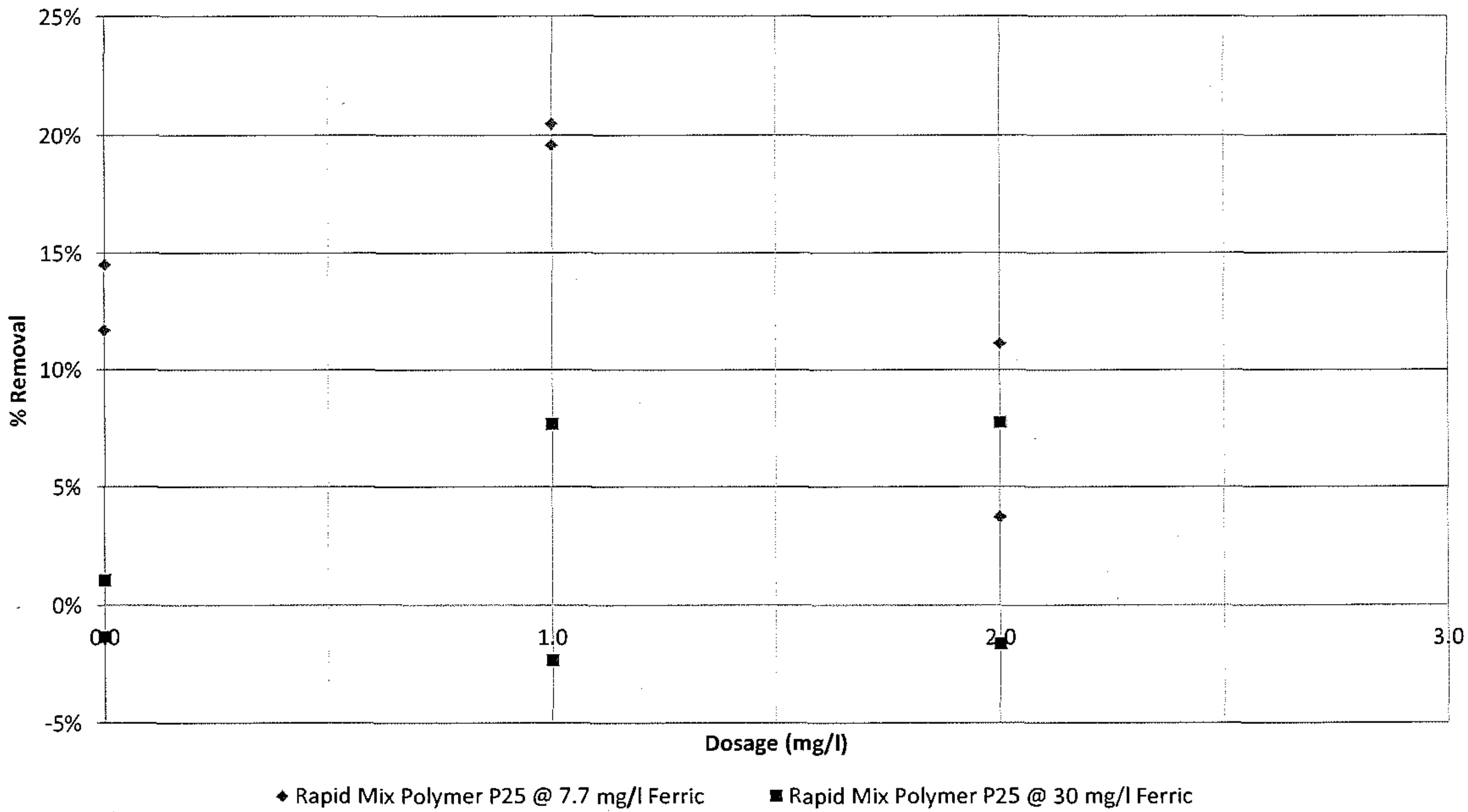
APPENDIX A
JAR TEST DATA

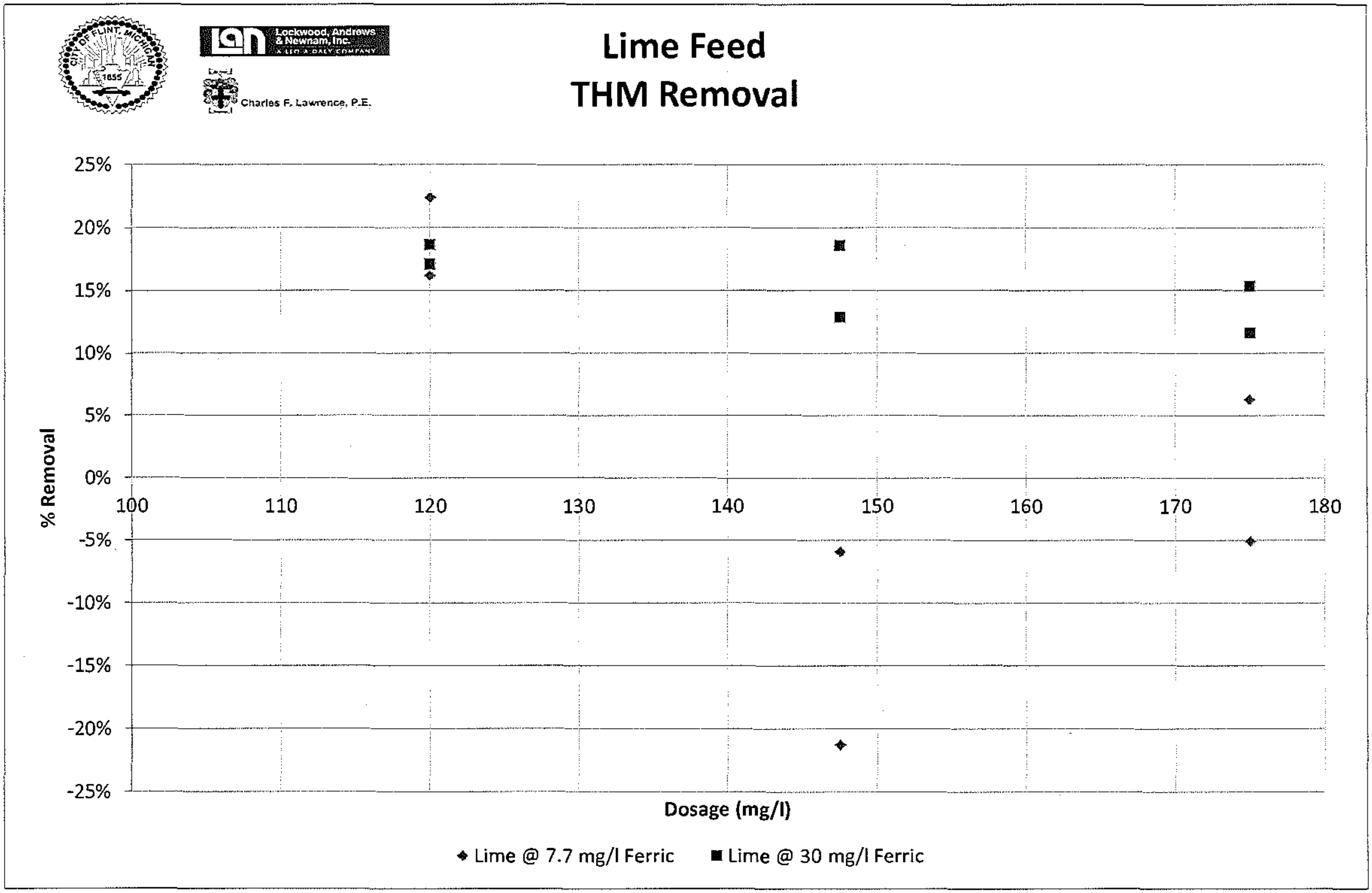

Ferric Chloride Feed
THM Removal
Lockwood, Andrews & Newnam, Inc.
Charles F. Lawrence, P.E.
% Removal
0%
10%
20%
30%
40%
50%
60%
70%
80%
Dosage (mg/l)
0
10
20
30
40
50
60
70
80
90

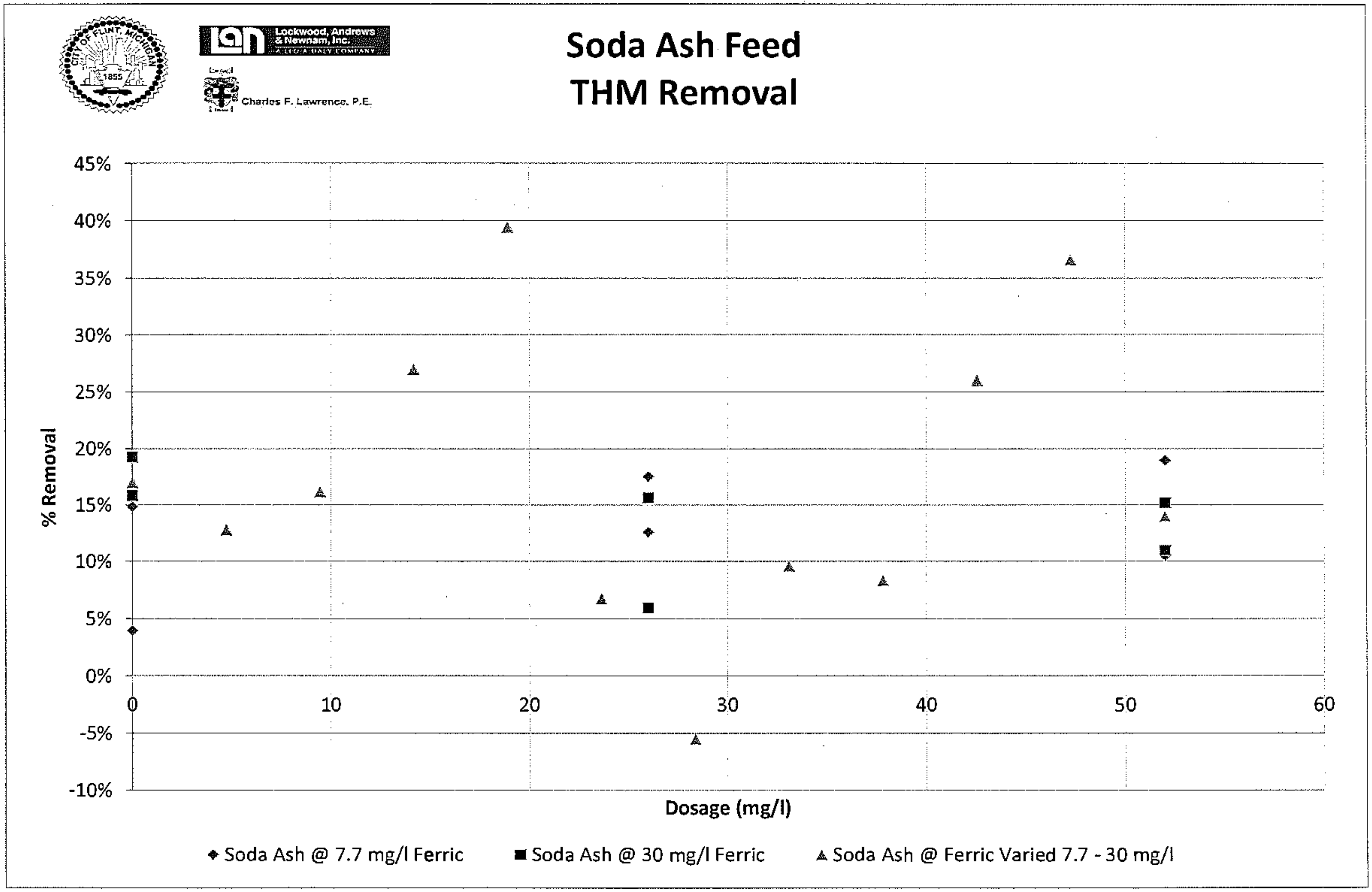
Lockwood, Andrews & Newnam, Inc. A LEO A DALY COMPANY

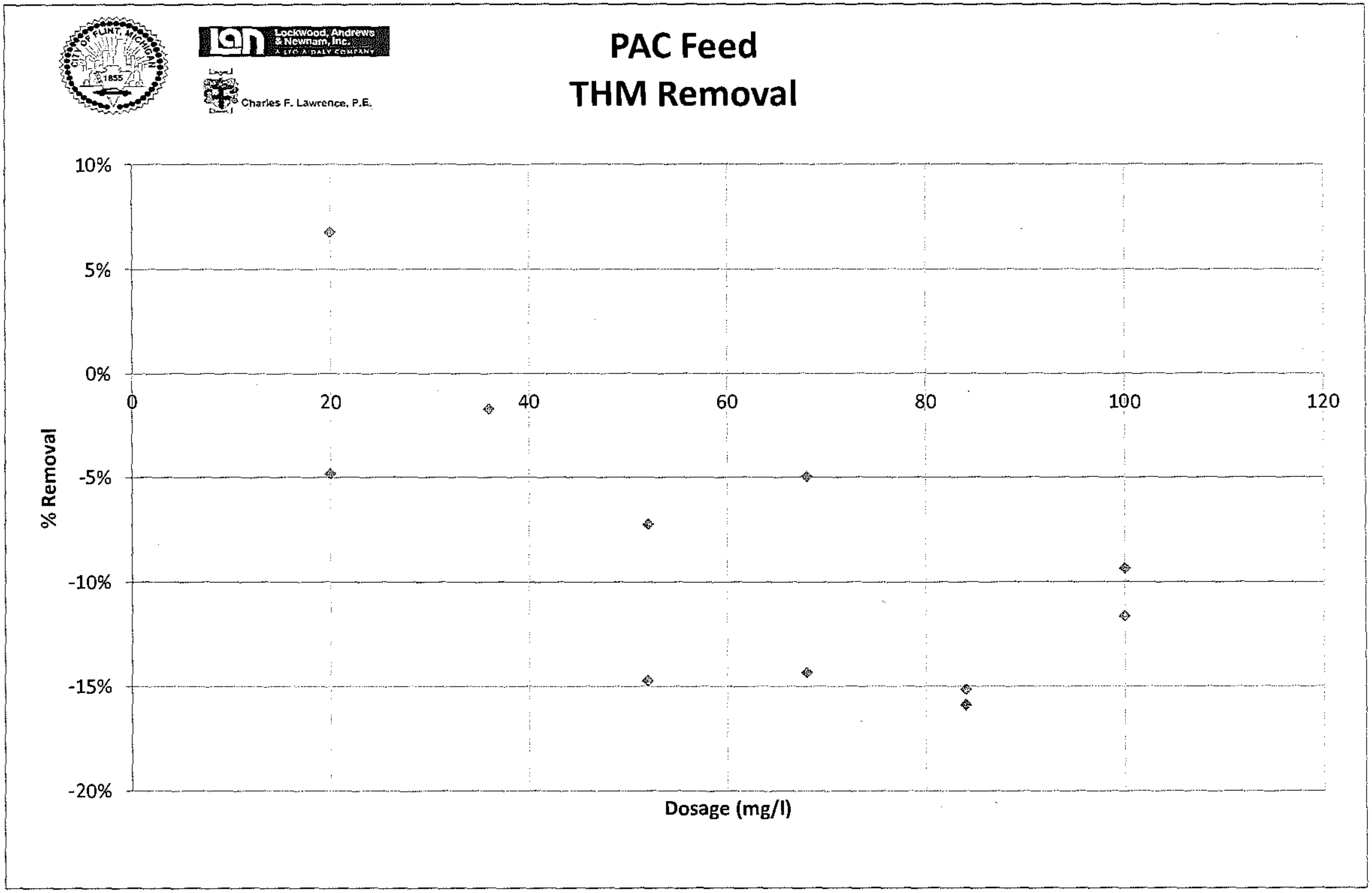
Charles F. Lawrence, P.E.

Coag/Floc Polymer Aid
THM Removal




Lockwood, Andrews & Newnam, Inc.
Charles F. Lawrence, P.E.
Lime Feed
THM Removal
% Removal
25%
20%
15%
10%
5%
0%
-5%
-10%
-15%
-20%
-25%
100
110
120
130
140
150
160
170
180
Dosage (mg/l)
Lime @ 7.7 mg/l Ferric
Lime @ 30 mg/l Ferric

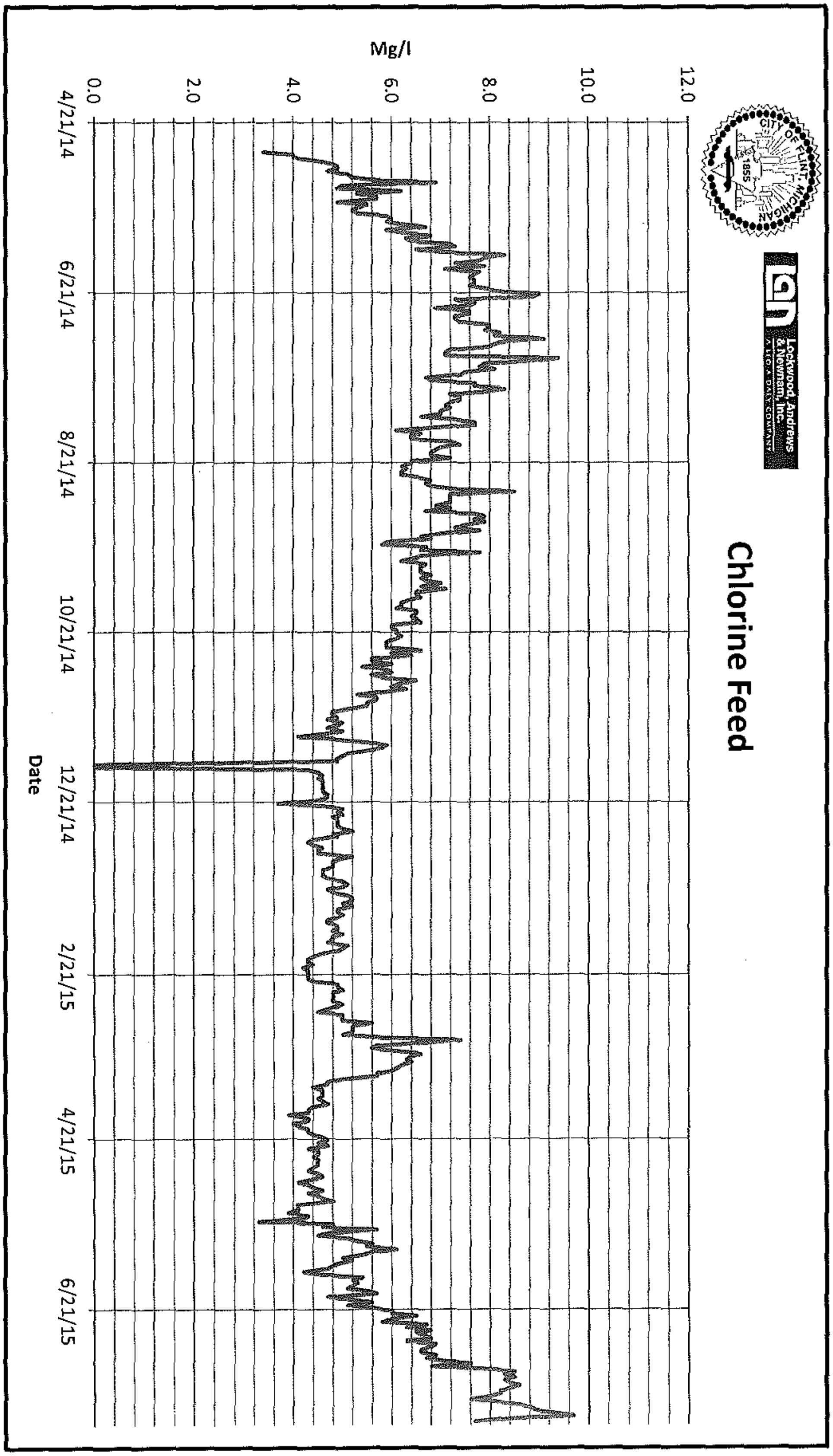

Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
Charles F. Lawrence, P.E.
Soda Ash Feed
THM Removal
% Removal
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
-5%
-10%
0
10
20
30
40
50
60
Dosage (mg/l)
Soda Ash @ 7.7 mg/l Ferric
Soda Ash @ 30 mg/l Ferric
Soda Ash @ Ferric Varied 7.7 - 30 mg/l



Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
Charles F. Lawrence, P.E.
PAC Feed
THM Removal
10%
5%
0%
-5%
-10%
-15%
-20%
% Removal
0
20
40
60
80
100
120
Dosage (mg/l)

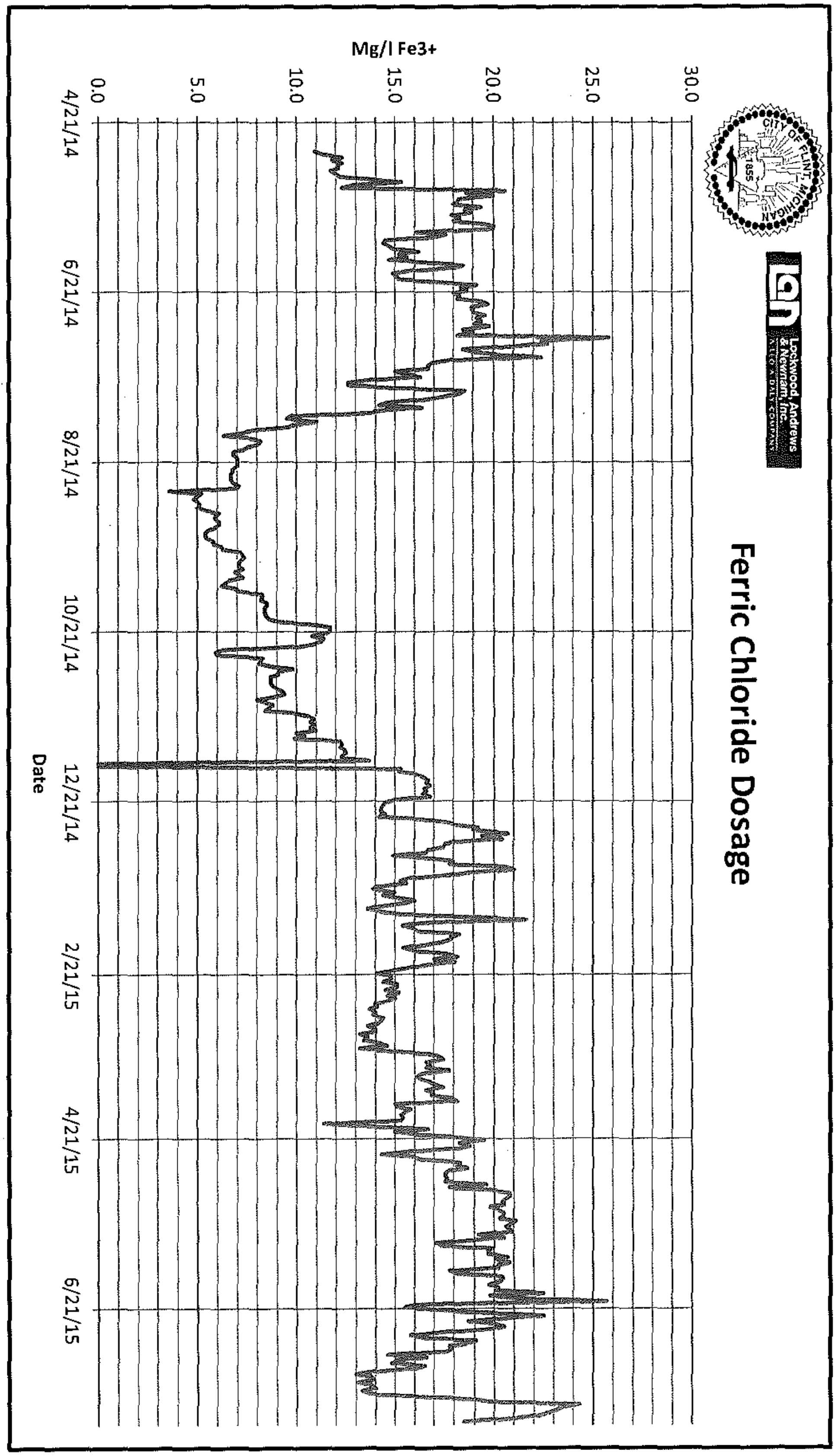
APPENDIX B
WTP DATA

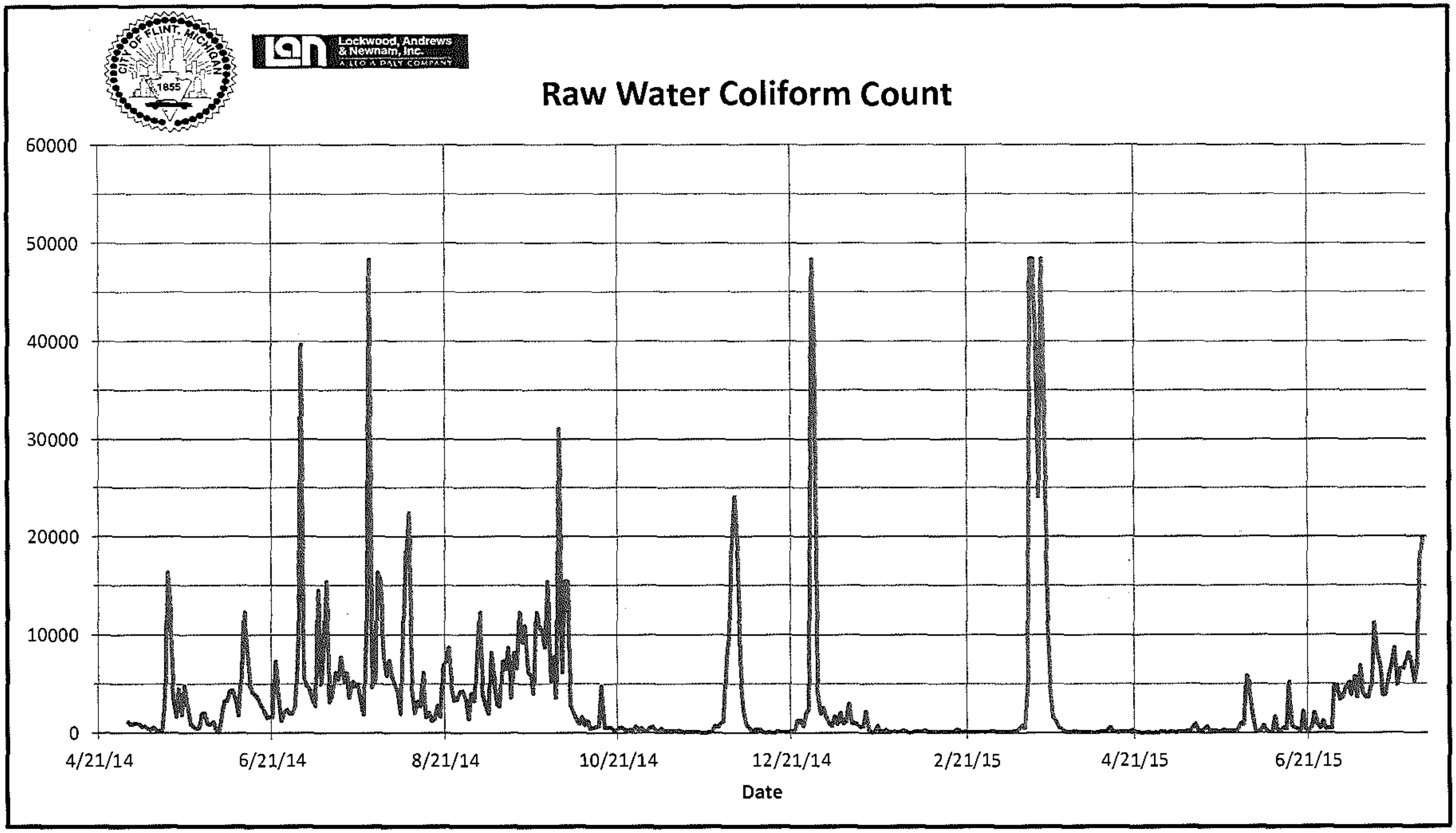
B-2



Chlorine Feed
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
CITY OF FLINT MICHIGAN
1855
Mg/l
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4/21/14
6/21/14
8/21/14
10/21/14
12/21/14
2/21/15
4/21/15
6/21/15
Date

B-3


CITY OF FLINT MICHIGAN
1855
Lockwood, Andrews & Newnam, Inc.
Ferric Chloride Dosage
Mg/l Fe3+
30.0
25.0
20.0
15.0
10.0
5.0
0.0
4/21/14
6/21/14
8/21/14
10/21/14
12/21/14
2/21/15
4/21/15
6/21/15
Date


CITY OF FLINT, MICHIGAN
1855
Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY
Raw Water Coliform Count
60000
50000
40000
30000
20000
10000
0
4/21/14
6/21/14
8/21/14
10/21/14
12/21/14
2/21/15
4/21/15
6/21/15
Date

Operational Evaluation Report
Trihalomethane Formation Concern

Headquarters
2925 Briarpark Drive
Suite 400
Houston, TX 77042
713.266.6900

info@lan-inc.com

Texas
Austin
College Station
Corpus Christi
Dallas
Fort Worth
Houston
San Antonio
San Marcos
Waco

Arizona
Phoenix

California
Huntington Baach
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Milpitas
Orange
Sacramento

Florida
Miami
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Illinois
Chicago

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Flint
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EXHIBIT JJ

STATE OF MICHIGAN
EXECUTIVE OFFICE
LANSING

RICK SNYDER
GOVERNOR

BRIAN CALLEY
LT. GOVERNOR

PROCLAMATION

DECLARATION OF EMERGENCY

WHEREAS, Section 1 of Article V of the Michigan Constitution of 1963 vests the executive power of the state of Michigan in the Governor; and

WHEREAS, under the Emergency Management Act, Act No. 390 of the Public Acts of 1976, as amended, MCL 30.401 to 30.421, the Governor is responsible for coping with dangers to this state or the people of this state presented by a disaster or emergency or threat thereof, and may issue executive orders and proclamations, having the force and effect of law to implement the Act; and

WHEREAS, under Section 3 of the Emergency Management Act, 1976 Public Act 390, MCL 30.403, the Governor shall, by executive order or proclamation, declare a state of emergency if the Governor finds that an emergency has occurred or that the threat of an emergency exists; and

WHEREAS, on April 25, 2014 the City of Flint, Michigan switched from the Detroit water system to the Flint River as a water source, the harmful effects of untreated water struck the city's water infrastructure, causing leaching of lead into the water which caused damage to the water system and potential negative health impacts to the citizens; and

WHEREAS, the area affected includes parts of the City of Flint, within the County of Genesee; and

WHEREAS, the damaged water infrastructure and leaching of lead into the city's water caused damage to public and private water infrastructure, and has either caused or threatened to cause elevated blood lead levels, especially in the population of children and pregnant women, and causing a potential immediate threat to public health and safety and disrupting vital community services; and

WHEREAS, from October 1, 2015 to this date, the County of Genesee and the City of Flint have taken a number of actions to cope with the situation, including but not limited to, switching back to the Detroit water system on October 16th, declaring local states of emergency, activating the emergency response and recovery aspects of their emergency operations plan, marshaling

and distributing required resources on a city-wide level, and issuing emergency public information and bulletins; and

WHEREAS, local resources have been insufficient to address the situation, and additional assistance from voluntary organizations and the state is required to protect public health, safety, and property, and to lessen or avert the threat of more severe and long lasting impacts to the community;

NOW, THEREFORE, I, RICHARD D. SNYDER, Governor of the state of Michigan, pursuant to the Constitution of the state of Michigan and provisions of Act No. 390 of the Public Acts of 1976, as amended, do hereby proclaim that a state of emergency exists in the aforementioned county and municipality; and

FURTHER, the Emergency Management and Homeland Security Division of the Department of State Police shall coordinate and maximize all state efforts, and may call upon all state departments to utilize resources at their avail to assist in the emergency area pursuant to the Michigan Emergency Management Plan; and

FURTHER, termination of this emergency will occur at such time as the threats to public health, safety, and property caused by the emergency no longer exist and appropriate programs have been implemented to recover from the effects of this emergency, but in no case longer than February 1, 2016, unless extended as provided by Act No. 390.

Given under my hand and the Great Seal of the State of Michigan this 5th day of January in the Year of Our Lord, Two Thousand and Sixteen.

RICHARD D. SNYDER
GOVERNOR

BY THE GOVERNOR:

SECRETARY OF STATE

FILED WITH SECRETARY OF STATE

ON 1/5/16 AT 4:00pm

EXHIBIT KK

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT AND COMPLIANCE ASSURANCE
WASHINGTON, D.C.

IN THE MATTER OF:	:	Proceedings Pursuant To
	:	Section 1431 of the Safe Drinking
City of Flint, Michigan; Michigan	:	Water Act, 42 U.S.C. § 300i
Department of Environmental	:	**SDWA-05-2016-0001**
Quality; and the State of Michigan,	:	EMERGENCY
	:	ADMINISTRATIVE ORDER
Respondents.	:	

I. INTRODUCTION

1. The Safe Drinking Water Act ("SDWA" or "Act") provides the U.S. Environmental Protection Agency ("EPA" or "Agency") with the authority to order actions when an imminent and substantial endangerment exists and the actions taken by the state and/or local authorities are inadequate to protect public health. EPA has determined that the City of Flint's and the State of Michigan's responses to the drinking water crisis in Flint have been inadequate to protect public health and that these failures continue. As a result, EPA is issuing this SDWA Emergency Order ("Order") to make sure that the necessary actions to protect public health happen immediately. The Order requires that necessary information be provided promptly to the public in a clear and transparent way to assure that accurate, reliable, and trustworthy information is available to inform the public and decisions about next steps. In addition to the issuance of this Order, EPA will promptly begin sampling and analysis of lead levels in tap water in the City of Flint's public water system ("PWS"). EPA will publish these sampling results on its website to provide the public with transparency into the process to abate the public health emergency in the City of

Flint. In the coming weeks, EPA may take additional actions under the SDWA to address the situation in the City of Flint.

II. STATUTORY AUTHORITY

2. This Order is issued under the authority vested in the Administrator of the EPA by Section 1431 of the SDWA, 42. U.S.C. § 300i. This Order is issued for the purpose of protecting the health of persons who are supplied drinking water by a PWS with conditions that may present an imminent and substantial endangerment to human health.

III. FINDINGS OF FACT

3. The City of Flint, Michigan ("City") owns and operates a PWS that provides piped drinking water for human consumption to its nearly 100,000 citizens.
4. From December 2011 through April 2015, an emergency manager was appointed by the State of Michigan ("State") under Public Act 436 to oversee the management of the City during its financial crisis. During that time, the City became a partner with the Karegnondi Water Authority ("KWA") and decided to no longer purchase treated drinking water from the Detroit Water and Sewerage Department ("Detroit").
5. The Michigan Department of Environmental Quality ("MDEQ") has primary responsibility for the implementation and enforcement of the public water system program in Michigan.
6. Before April 2014, the City purchased finished drinking water from Detroit.
7. On or around April 25, 2014, the City ceased purchasing treated drinking water from Detroit and began drawing water from the Flint River as its source water.

8. Between July and December 2014, the City conducted the first of two rounds of six month lead sampling under the Lead and Copper Rule ("LCR"), 40 C.F.R. § 141.80 *et seq*.
9. The City conducted the second of two rounds of six month lead sampling under the LCR between January and June 2015. These rounds of sampling showed that the levels of lead in the City water supply were rapidly rising.
10. On or about April 24, 2015, MDEQ notified EPA that the City did not have corrosion control treatment in place at the Flint Water Treatment Plant.
11. During May and June, 2015, EPA Region 5 staff at all levels expressed concern to MDEQ and the City about increasing concentrations of lead in Flint drinking water and conveyed its concern about lack of corrosion control and recommended that the expertise of EPA's Office of Research and Development should be used to avoid further water quality problems moving forward.
12. On July 21, 2015, EPA Region 5 discussed with MDEQ the City's lead in drinking water issues and implementation of the LCR and MDEQ agreed to require corrosion control as soon as possible.
13. On August 17, 2015, MDEQ sent a letter to the City recommending the City implement corrosion control treatment as soon as possible, but no later than January 1, 2016, and to fully optimize its treatment within six months.
14. On August 31, 2015, EPA Region 5 had a call with MDEQ to discuss outreach to citizens to reduce exposures to high lead levels in Flint drinking water and reiterate EPA's offer of technical assistance in implementing corrosion control treatment.

15. On September 3, 2015, Flint Mayor Dayne Walling announced that the City will implement corrosion control treatment and invited EPA corrosion control experts to join the Flint Technical Advisory Committee ("Flint TAC").
16. On September 27, 2015, EPA Region 5 Administrator Susan Hedman called MDEQ Director Dan Wyant to discuss the need for expedited implementation of corrosion control treatment, the importance of following appropriate testing protocols, urged MDEQ to enlist Michigan Department of Health and Human Services' involvement and discussed options to provide bottled water/premixed formula/filters until corrosion control is optimized.
17. On October 7, 2015, the Flint TAC met about the City's corrosion control and treatment. The Flint TAC recommended returning to Detroit water as the best course of action for the City.
18. On October 16, 2015, EPA established the Flint Safe Drinking Water Task Force ("EPA Flint Task Force") to provide the Agency's technical expertise through regular dialogue with designated officials from MDEQ and the City.
19. On or around October 16, 2015, the City switched back to purchasing finished water from Detroit, now called the Great Lakes Water Authority.
20. On November 25, 2015, the EPA Flint Task Force requested information that would allow EPA to determine the progress being made on corrosion control in the City; this information has not been received by EPA. This information includes water quality parameter measurements (pH, total alkalinity, orthophosphate, chloride, turbidity, iron, calcium, temperature, conductivity) in the distribution system. The EPA Flint Task Force has also made subsequent requests and recommendations.

http://www.epa.gov/mi/flint-drinking-water-documents The City is required by its MDEQ permit to monitor for these parameters at 25 sites quarterly and at 10 of these sites weekly. Because the City has not provided the information requested by the EPA Flint Task Force EPA does not have the information that would provide any assurance that contamination in the City's water system has been controlled.

21. On or around December 9, 2015, the City began feeding additional orthophosphate at the Flint Water Treatment Plant to begin optimizing corrosion control treatment. Notwithstanding the orthophosphate addition, high levels of lead and other contaminants are presumed to persist in the City's water system until LCR optimization process, utilizing sampling and monitoring requirements, have confirmed lead levels have been reduced.
22. On December 14, 2015 the City declared an emergency.
23. On January 14, 2016, the Governor of the State requested a declaration of major disaster and emergency and requested federal aid.
24. On January 16, 2016, the President of the United States declared a federal emergency in the City.
25. The presence of lead in the City water supply is principally due to the lack of corrosion control treatment after the City's switch to the Flint River as a source in April 2014. The river's water was corrosive and removed protective coatings in the system. This allowed lead to leach into the drinking water, which can continue until the system's treatment is optimized.
26. Lead occurs in drinking water from two sources: lead in raw water supplies and corrosion of plumbing materials in the water distribution system (i.e., corrosion

byproducts). Most lead contamination is from corrosion byproducts. The amount of lead in drinking water attributable to corrosion byproducts depends on a number of factors, including the amount and age of lead bearing materials susceptible to corrosion, how long the water is in contact with the lead containing surfaces, and how corrosive the water in the system is toward these materials. *Final Rule: Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper*, 56 *Fed. Reg*. 26460, 26463 (June 7, 1991).

27. EPA has set the Maximum Contaminant Level Goal ("MCLG") at zero for lead because (1) there is no clear threshold for some non-carcinogenic lead health effects, (2) a substantial portion of the sensitive population already exceeds acceptable blood lead levels, and (3) lead is a probable carcinogen. 56 *Fed. Reg.* at 26467. Pregnant women, unborn children, and children under the age of six are particularly sensitive to lead exposure.

28. The concentration of lead in whole blood has been the most widely used index of total lead exposure. Lead exposure across a broad range of blood lead levels has been associated with a spectrum of patho-physiological effects, including interference with heme synthesis necessary in the formation of red blood cells, anemia, kidney damage, impaired reproductive function, interference with vitamin D metabolism, impaired cognitive performance (as measured by IQ tests, performance in school, and other means), delayed neurological physical development, and elevation in blood pressure. 56 Fed. Reg. 26467-68.

29. EPA finds that consumption of lead in water contributes to increase in blood lead levels. The Centers for Disease Control and Prevention uses a reference level of 5

micrograms per deciliter to identify children with elevated blood lead levels. This new level is based on the U.S. population of children ages 1 – 5 years who are in the highest 2.5% of children when tested for lead in their blood. http://www.cdc.gov/nceh/lead/acclpp/blood_lead_levels.htm

30. Under the LCR, the "action level" for lead is the concentration of lead at which corrective action is required. 40 C.F.R. § 141.2.

31. EPA's LCR includes requirements for corrosion control treatment, source water treatment, lead service line replacement, and public education. These requirements are triggered, in some cases, by lead and copper action levels measured in samples collected at consumers' taps. The action level for lead is exceeded if the concentration of lead in more than 10 percent of tap water samples collected during the monitoring period conducted in accordance with 40 C.F.R. § 141.86 is greater than 0.015mg/L (i.e., if the "90^{th} percentile" is greater than 0.015mg/L). 40 C.F.R. § 141.80(c). When a large system exceeds this action level, the LCR requires the system to: 1) implement public education requirements; 2) implement all applicable source water treatment requirements specified by the primacy agency under 40 C.F.R. § 141.83; and (3) if the system is exceeding the action level after implementation of all applicable corrosion control and source water treatment requirements, then the system must replace lead service lines in accordance with 40 C.F.R. § 141.84.

32. All large systems (over 50,000 persons) are required to either complete corrosion control treatment steps in 40 C.F.R. § 141.91(d) or be deemed to have optimized corrosion control treatment under 40 C.F.R. § 141.81(b)(2) or (b)(3).

33. Based on the foregoing, EPA finds that water provided by the City to residents poses an imminent and substantial endangerment to the health of those persons. Those persons' health is substantially endangered by their ingestion of lead in waters that persons legitimately assume are safe for human consumption. This imminent and substantial endangerment will continue unless preventive actions are taken.

34. The City, MDEQ and the State have failed to take adequate measures to protect public health. Although some progress has been made in addressing the drinking water crisis in the City, there continue to be delays in responding to critical EPA recommendations and in implementing the actions necessary to reduce and minimize the presence of lead and other contaminants in the water supply both now and in the near future. The Respondents have failed and continue to fail to provide the information necessary for EPA, the EPA Flint Task Force and the City's PWS customers to fully understand and respond promptly and adequately to the current deficiencies. EPA remains concerned that the City lacks the professional expertise and resources needed to carry out the recommended actions and to safely manage the City's PWS.

35. In accordance with SDWA Section 1431(a), 42 U.S.C. § 300i(a), to the extent practicable EPA has consulted with state and local authorities regarding the information on which this EPA action is based.

36. This Order and the requirements set forth herein are necessary to ensure adequate protection of public health in the City.

37. As a result of the emergency, EPA will promptly begin sampling and analysis of lead levels and other contaminants in the City to assure that all regulatory authorities and the public have accurate and reliable information.

38. EPA will make its LCR sampling results available to the public on the Agency's website.

IV. CONCLUSIONS OF LAW

39. Section 1431 (a), 42 U.S.C. § 300i(a), specifies that the EPA Administrator, upon receipt of information that a contaminant which is present in or likely to enter a public water system that may present an imminent and substantial endangerment to the health of persons, and that State and local authorities have not acted to protect the health of such persons, may take such actions as she may deem necessary in order to protect the health of such persons.

40. The City owns and operates a "public water system" within the meaning of SDWA Section 1401.

41. MDEQ is an instrumentality of the State.

42. The City, State and MDEQ are "persons" as defined in SDWA Section 1401(c)(12).

43. Respondents' cessation of purchased water from Detroit and switch to the Flint River as its source water triggered a cascade of events that directly resulted in the contribution of lead and other "contaminants" that are within the meaning of SDWA Sections 1401(c)(6) and 1431 of the Act.

44. The contaminants introduced by Respondents are present in or likely to enter a PWS.

45. Based upon the information and evidence, EPA determines that Respondents' actions that resulted in the introduction of contaminants, which entered a public water system

and have been consumed and may continue to be consumed by those served by the public water system, present an imminent and substantial endangerment to the health of persons.

46. The lead and other contaminants will remain present in the PWS and will continue to present an imminent and substantial endangerment to the health of persons until the underlying problems with the corrosion control treatment and fundamental deficiencies in the operation of the PWS are corrected and sampling results confirm the lead and other contaminants are adequately treated.

47. Respondents have failed to take adequate measures to protect public health.

48. The EPA has consulted with the State and local authorities, to the extent practicable, to confirm the correctness of the information upon which this ORDER is based and to ascertain the actions which such authorities are or will be taking. All requisite conditions have been satisfied for the EPA action under SDWA Section 1431(a)(1), 42 U.S.C. § 300i(a)(1).

49. The EPA finds that there is an imminent and substantial endangerment to the people drinking water from the public water system of the City of Flint and that the actions taken by the State and/or the City are inadequate to protect public health. The actions required by this ORDER are necessary to protect the health of persons who are currently consuming or who may consume or use water from the City's PWS.

V. <u>ORDER</u>

Based on the foregoing Findings and Conclusions, and pursuant to Section 1431 of the Act, 42 U.S.C. 300i,

IT IS ORDERED:

Intent to Comply

50. Within one day of the effective date of this Order, Respondents shall notify EPA in writing of their intention to comply with the terms of this Order. For the purposes of this Order, "day" shall mean calendar day.

Reporting Requirements

51. Within five days of the effective date of this Order, the State shall create, and thereafter maintain, a publicly available website. Respondents must post on this website all reports, sampling results, plans, weekly status reports on the progress of all requirements and all other documentation required under this Order. The Respondents shall not publish to this website any personally identifiable information.

Response to EPA Flint Task Force Recommendations, Requests for Information and Sampling Activities

52. The Respondents shall within 10 days of the effective date of this Order respond in writing, in accordance with Paragraph 51, to all of the EPA Flint Task Force's requests and recommendations made on November 25, 2015 and subsequent dates. The response shall include all actions Respondents have taken and intend to take in response to those requests and recommendations. The EPA Flint Task Force's requests and recommendations are publicly available at http://www.epa.gov/mi/flint-drinking-water-documents.

53. Within 10 days of the effective date of the Order the Respondents shall provide the following information in accordance with Paragraph 51:

    a. Water quality parameter measurements (pH, total alkalinity, orthophosphate, chloride, turbidity, iron, calcium, temperature, conductivity) in the distribution

system. The City is required by the MDEQ permit to monitor for these parameters at 25 sites quarterly and at 10 of these sites weekly;

b. All lead in water testing results for the City since January 2013, including those not used for LCR compliance; and

c. Identification of areas (e.g., zip codes, neighborhoods) in the City with elevated blood lead levels.

54. Within 10 days of the effective date of the Order, the Respondents shall provide, without publicly disclosing any personally identifiable information, the following directly to the EPA in accordance with Paragraph 66:

a. Existing inventory of homes with lead service lines in Excel or a similar format;

b. Addresses of homes that have had water service interruptions or street disturbances (e.g., water main breaks, road/sidewalk construction, etc.) within the last year; and

c. Addresses of currently unoccupied homes.

55. Respondents shall cooperate with EPA as the Agency conducts LCR sampling and other diagnostic activities in the City.

<u>Treatment and Source Water</u>

56. To ensure that treated water meets finished water quality goals and is consistently maintained throughout the distribution system, that existing and potential plant operational and mechanical start-up issues are identified and addressed, and that water plant operations staff are proficient in treating the existing and new source water, Respondents shall comply with Paragraphs 57, 58 and 59.

57. Respondents shall maintain chlorine residual in the distribution system in accordance with SDWA and the National Primary Drinking Water Regulations ("NPDWRs").

58. The City shall continue to add corrosion inhibitors (e.g., orthophosphate booster) at levels sufficient to re-optimize corrosion control in the distribution system.

59. To address optimization of corrosion control for the system as operated with its current water source, within 14 days of the effective date of this Order the Respondents shall submit to MDEQ and post in accordance with Paragraph 51:

   a. Submit a plan and schedule to the MDEQ to review and revise as needed designated optimal corrosion control and water quality parameters as well as monitoring plans for LCR compliance and all other monitoring plans developed to ensure that the treatment plant is consistently and reliably meeting plant performance criteria and all other NPDWRs;

   b. Submit a sampling plan for daily monitoring of water quality parameters in the distribution system with results compiled in a weekly report in an approved format; and

   c. Submit an operations plan for the corrosion control equipment (storage day tanks, feed/injection systems), with results compiled in a weekly format, that includes monitoring, calibration, verification (pump catch, etc.) as well as daily monitoring of finished water corrosion control parameters. Results shall be submitted and posted weekly.

60. Respondents shall not effectuate a transition to a new water source for the City's PWS (e.g., from KWA) until such time as they have submitted a written plan, developed through consultation with appropriate experts and after providing adequate

advanced notice and an opportunity for public comment, to MDEQ and in accordance with Paragraph 51, demonstrating that the City has the technical, managerial and financial capacity to operate its PWS in compliance with SDWA and the NPDWRs and that necessary infrastructure upgrades, analysis, and testing have been completed to ensure a safe transition. Such plans shall include, but not be limited to, provisions addressing:

a. The impacts on corrosion control for any new source water and an operations plan for periodic use of existing sources of water;

b. Completion of corrosion control study for any new sources;

c. Implementation of a "performance period" that allows for the demonstration of the adequacy of treatment of the new water source to meet all NPDWRs before it can be distributed to residents; and

d. The City's technical, managerial and financial capacity to meet SDWA's applicable requirements, including the NPDWRs, during and after the transition to any new water source.

<u>Treatment and Distribution System Management</u>

61. Within 15 days of the effective date of this Order, the City must demonstrate, and the MDEQ and State must ensure, the City has the necessary, capable and qualified personnel required to perform the duties and obligations required to ensure the PWS complies with the SDWA and the NPDWRs.

62. To ensure the City's PWS is adequately operated to meet SDWA and all NPDWRs, within 30 days of the effective date of this Order, the Respondents shall submit the steps they will take to develop and implement a distribution system water quality

optimization plan to MDEQ and in accordance with Paragraph 51, to evaluate and improve its programs that affect distribution system water quality, including: evaluating conditions within the distribution system; creating better documentation; and enhancing communication between the various utility functions that impact distribution system water quality. The MDEQ must ensure that this plan is adequate to ensure SDWA compliance and the State must ensure it is executed.

Independent Advisory Panel ("IAP")

63. Within seven days of the effective date of this Order, the MDEQ and State, with the City's input and concurrence, shall engage a panel of independent, nationally-recognized experts on drinking water treatment, sampling, distribution system operation, and members of the affected community to advise and make public recommendations to the City on steps needed to mitigate the imminent and substantial endangerment to the health of persons and general operation of the City's PWS to ensure compliance with SDWA and the NPDWRs.

64. The charge to the IAP will include the following:

a. Make recommendations to the Respondents, and for consideration by the EPA, to ensure the safe operation of the City's PWS.

b. Make other recommendations to the Respondents, and for consideration by the EPA, to better serve the community served by the City's PWS.

VI. PARTIES BOUND

65. The provisions of this Order shall apply to and bind Respondents and their officers, employees, agents, successors and assigns.

VII. GENERAL PROVISIONS

66. All submittals and inquiries pursuant to this Order shall be addressed to:

Mark Pollins, Director
Water Enforcement Division
Office of Enforcement and Compliance Assurance
United States Environmental Protection Agency
William Jefferson Clinton South Building
1200 Pennsylvania Avenue NW
Room 3104
Washington, DC 20460
pollins.mark@epa.gov

67. All plans, reports, notices or other documents submitted by Respondents under this Order shall be accompanied by the following statement signed by a responsible official.

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering such information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

68. Record preservation. Respondents shall retain, during the pendency of this Order, and for a minimum of six years after its termination, all data, records and documents in its possession or control, or which comes into its possession or the possession of its divisions, officers, directors, employees, agents, contractors, successors, and assigns, which relate in any way to this Order. After the above mentioned six year period, Respondents shall provide written notification to EPA 60 calendar days before the destruction of any data, records, or documents that relate in any way to this Order or its implementation. At the EPA's request, Respondents shall then make records available to the EPA for inspection and/or retention, or shall provide copies of any such records to EPA before discarding.

69. Within 10 days of the effective date of this Order, or at the time of retaining any agent, consultant, or contractor for the purpose of carrying out terms of this Order, Respondents shall enter into an agreement with any such agents, consultants, or contractors whereby such agents, consultants, or contractors will be required to provide Respondents a copy of all documents produced under this Order.

70. EPA retains all of its information gathering and inspections authorities and rights, including the right to bring enforcement actions related thereto, under SDWA and any other applicable statutes or regulations.

71. Pursuant to SDWA Section 1431(b), 42 U.S.C. § 300i, in the event Respondents violate, fail or refuse to comply with any of the terms or provisions of this Order, EPA may commence a civil action in U.S. District Court to require compliance with this Order and to assess a civil penalty of up to $21,500 per day of violation under SDWA, as adjusted by the Federal Civil Penalties Inflation Adjustment Act of 1990, amended by the Debt Collection Improvement Act of 1996, and the subsequent Civil Monetary Penalty Inflation Adjustment Rule, 40 C.F.R. Part 19.

72. Compliance with the terms and conditions of this Order shall not in any way be construed to relieve Respondents of their obligations to comply with all applicable provisions of federal, state, or local law, nor shall it be construed to be a determination of any issue related to any federal, state, or local permit. Compliance with this Order shall not be a defense to any actions subsequently commenced for any violation of federal laws and regulations administered by EPA, and it is the responsibility of Respondents to comply with such laws and regulations.

73. EPA may modify this Order to ensure protection of human health and the environment. Such modification shall be in writing and shall be incorporated into this Order.

74. This Order shall constitute final agency action by EPA.

VIII. EFFECTIVE DATE

75. Under SDWA Section 1431, 42 U.S.C. § 300i, this Order shall be effective immediately upon Respondents' receipt of this Order. If modifications are made by the EPA to this Order, such modifications will be effective on the date received by Respondents. This Order shall remain in effect until the provisions identified in the Order have been met in accordance with written EPA approval.

IX. TERMINATION

76. The provisions of this Order shall be deemed satisfied upon Respondents' receipt of written notice from the EPA that Respondents have demonstrated, to the satisfaction of the EPA, that the terms of this Order, including any additional tasks determined by EPA to be required under this Order or any continuing obligation or promises, have been satisfactorily completed.

1/21/16
Date

Cynthia Giles

CYNTHIA GILES
Assistant Administrator
Office of Enforcement and Compliance Assurance
United States Environmental Protection Agency
William Jefferson Clinton South Building
1200 Pennsylvania Avenue N.W.
Washington, DC 20460

EXHIBIT LL

NSPE® NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

Code of Ethics for Engineers

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. **Engineers shall hold paramount the safety, health, and welfare of the public.**
   a. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.
   b. Engineers shall approve only those engineering documents that are in conformity with applicable standards.
   c. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.
   d. Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.
   e. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.
   f. Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.

2. **Engineers shall perform services only in the areas of their competence.**
   a. Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.
   b. Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.
   c. Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provided that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.

3. **Engineers shall issue public statements only in an objective and truthful manner.**
   a. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.
   b. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.
   c. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

4. **Engineers shall act for each employer or client as faithful agents or trustees.**
   a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.
   b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
   c. Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.
   d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.
   e. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.

5. **Engineers shall avoid deceptive acts.**
   a. Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers, or past accomplishments.
   b. Engineers shall not offer, give, solicit, or receive, either directly or indirectly, any contribution to influence the award of a contract by public authority, or which may be reasonably construed by the public as having the effect or intent of influencing the awarding of a contract. They shall not offer any gift or other valuable consideration in order to secure work. They shall not pay a commission, percentage, or brokerage fee in order to secure work, except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

III. Professional Obligations

1. **Engineers shall be guided in all their relations by the highest standards of honesty and integrity.**
   a. Engineers shall acknowledge their errors and shall not distort or alter the facts.
   b. Engineers shall advise their clients or employers when they believe a project will not be successful.
   c. Engineers shall not accept outside employment to the detriment of their regular work or interest. Before accepting any outside engineering employment, they will notify their employers.
   d. Engineers shall not attempt to attract an engineer from another employer by false or misleading pretenses.
   e. Engineers shall not promote their own interest at the expense of the dignity and integrity of the profession.

2. **Engineers shall at all times strive to serve the public interest.**
   a. Engineers are encouraged to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community.
   b. Engineers shall not complete, sign, or seal plans and/or specifications that are not in conformity with applicable engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.
   c. Engineers are encouraged to extend public knowledge and appreciation of engineering and its achievements.
   d. Engineers are encouraged to adhere to the principles of sustainable development[1] in order to protect the environment for future generations.

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e. Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars.

3. Engineers shall avoid all conduct or practice that deceives the public.

a. Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact.
b. Consistent with the foregoing, engineers may advertise for recruitment of personnel.
c. Consistent with the foregoing, engineers may prepare articles for the lay or technical press, but such articles shall not imply credit to the author for work performed by others.

4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.

a. Engineers shall not, without the consent of all interested parties, promote or arrange for new employment or practice in connection with a specific project for which the engineer has gained particular and specialized knowledge.
b. Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the engineer has gained particular specialized knowledge on behalf of a former client or employer.

5. Engineers shall not be influenced in their professional duties by conflicting interests.

a. Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.
b. Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the engineer in connection with work for which the engineer is responsible.

6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.

a. Engineers shall not request, propose, or accept a commission on a contingent basis under circumstances in which their judgment may be compromised.
b. Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical considerations.
c. Engineers shall not, without consent, use equipment, supplies, laboratory, or office facilities of an employer to carry on outside private practice.

7. Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.

a. Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.
b. Engineers in governmental, industrial, or educational employ are entitled to review and evaluate the work of other engineers when so required by their employment duties.
c. Engineers in sales or industrial employ are entitled to make engineering comparisons of represented products with products of other suppliers.

8. Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.

a. Engineers shall conform with state registration laws in the practice of engineering.
b. Engineers shall not use association with a nonengineer, a corporation, or partnership as a "cloak" for unethical acts.

9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

a. Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.
b. Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the engineer for others without express permission.
c. Engineers, before undertaking work for others in connection with which the engineer may make improvements, plans, designs, inventions, or other records that may justify copyrights or patents, should enter into a positive agreement regarding ownership.
d. Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property. The employer should indemnify the engineer for use of the information for any purpose other than the original purpose.

Footnote 1 "Sustainable development" is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development.

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount."

Statement by NSPE Executive Committee

In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding."

It is further noted that as made clear in the Supreme Court decision:

1. Engineers and firms may individually refuse to bid for engineering services.
2. Clients are not required to seek bids for engineering services.
3. Federal, state, and local laws governing procedures to procure engineering services are not affected, and remain in full force and effect.
4. State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.
5. State registration board rules of professional conduct, including rules prohibiting competitive bidding for engineering services, are not affected and remain in full force and effect. State registration boards with authority to adopt rules of professional conduct may adopt rules governing procedures to obtain engineering services.
6. As noted by the Supreme Court, "nothing in the judgment prevents NSPE and its members from attempting to influence governmental action . . ."

Note: In regard to the question of application of the Code to corporations vis-a-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer, and it is incumbent on members of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.